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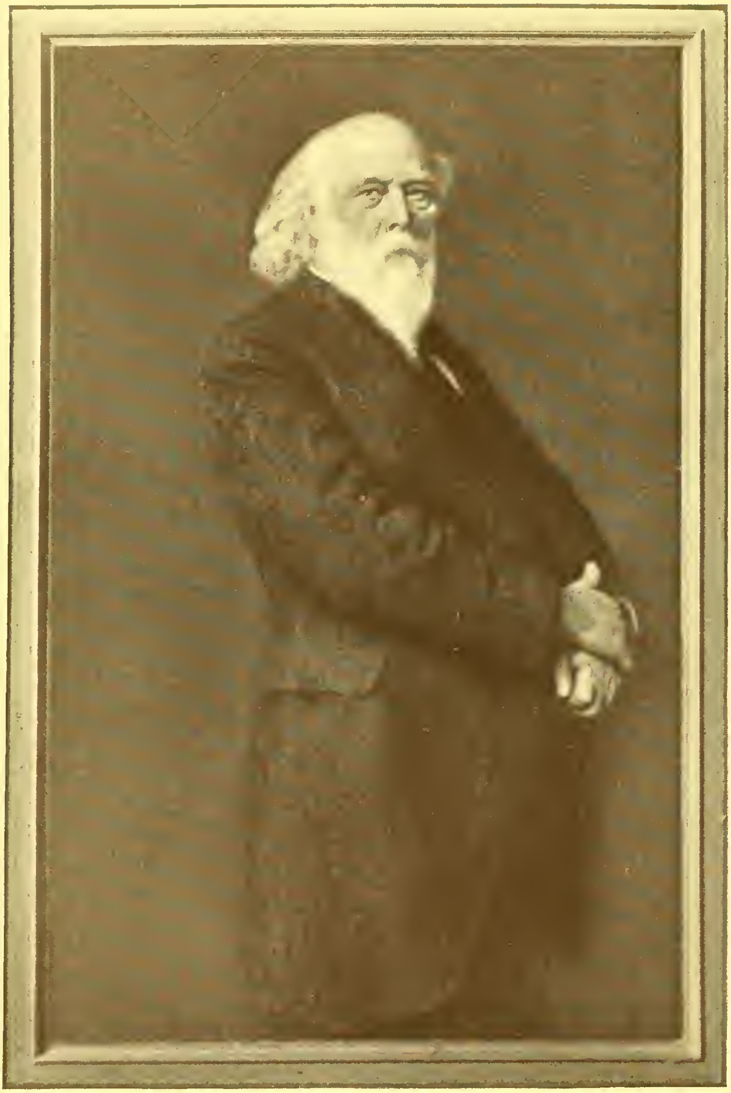
THE
JOURNAL

THE AMERICAN SOCIETY
OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

MAY 1909

SPRING MEETING, WASHINGTON, D. C., MAY 4-7



REAR-ADMIRAL GEORGE W. MELVILLE, RETIRED

FORMER ENGINEER-IN-CHIEF OF THE NAVY AND PRESIDENT AM. SOC. M. E., 1899

FROM PORTRAIT BY SIGISMOND DE IVANOWSKI

SEE PROGRAM
OF THE WASHINGTON MEETING

MAY 1909 VOL. 31 No. 5

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLISHED AT 2427 YORK ROAD - - - - BALTIMORE, MD.
EDITORIAL ROOMS, 29 W. 39TH STREET - - - - NEW YORK

CONTENTS

Frontispiece, Rear-Admiral Melville
Society Affairs.......... 3
Spring Meeting (3), General Notes (10), Meeting of the Council (16), John Fritz Medal Award (20), Memorial, A. R. Wolff (26), Necrology (29), Other Societies (31), Personals (35).
Papers
Specific Volume of Saturated Steam, C. H. Peabody.......... 595
Automatic Feeders for Handling Material in Bulk, C. Kemble Baldwin,.... 605
Polishing Metals for Examination with the Microscope, A. Kingsbury,.... 615
A New Transmission Dynamometer, Wm. H. Kenerson.......... 619
Small Steam Turbines, Geo. A. Orrok.......... 627
Operation of a Small Producer Gas-Power Plant, C. W. Obert.......... 653
Some Properties of Steam, R. C. H. Heck.......... 663
Marine Producer Gas Power, C. L. Straub.......... 673
A Unique Belt Conveyor, Ellis C. Soper.......... 689
Accessions to the Library.......... 697
Comment on Current Books.......... 705
Employment Bulletin.......... 708
Changes in Membership.......... 711
Coming Meetings.......... 715
Officers and Committees.......... 722

The Journal is published by The American Society of Mechanical Engineers twelve times a year, monthly except in July and August, semi-monthly in October and November.
Price, one dollar per copy—fifty cents per copy to members. Yearly subscription, $7.50; to members, $5.

Application filed for entry at the Postoffice, Baltimore, Md. as second-class mail matter under the act of March 3, 1879

The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 31 MAY 1909 NUMBER 5

WASHINGTON MEETING

PROGRAM

Tuesday, May 4

8.15 p.m.

Reception of the members by the Washington Society of Engineers, at the New Willard Hotel. Music by the Marine Band.

Address of welcome by Hon. Henry B. F. Macfarland, President of the Board of District Commissioners.

Response by Mr. Jesse M. Smith, President of the Society.

Wednesday, May 5

PROFESSIONAL SESSION, 9.15 A. M.

Business Meeting. Reports of Committees, Tellers of Election, New Business.

A UNIQUE BELT CONVEYER, Ellis C. Soper.

AUTOMATIC FEEDERS FOR HANDLING MATERIAL IN BULK, C. Kemble Baldwin.

A NEW TRANSMISSION DYNAMOMETER[1], Prof. Wm. H. Kenerson.

POLISHING METALS FOR EXAMINATION WITH THE MICROSCOPE,[1] Albert Kingsbury.

Sight-seeing automobile trips about the city at 10 a.m. for the ladies.

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[1] To be presented by title or in brief abstract.

WEDNESDAY AFTERNOON

Special exhibition drill by troops at Fort Myer, 2.30 p.m.

Take special cars in front of the New Willard Hotel at 1 p.m. for the trip to Fort Myer.

Trips to nearby points of interest at 4 p.m.

WEDNESDAY, 8.15 P.M.

Illustrated lecture by F. H. Newell, Director of the Reclamation Service, on "Home-Making in the Arid Regions."

Ladies are specially invited.

Thursday, May 6

THE GAS POWER SECTION 9.15 A. M.

Report of the Standardization Committee.

Marine Producer Gas Power, C. L. Straub.

Operation of a Small Producer Gas Power Plant, C. W. Obert.

A Method of Improving the Efficiency of Gas Engines, Thos. E. Butterfield.

Offsetting Cylinders in Single-Acting Engines, Prof. T. M. Phetteplace.

Trips for the ladies to points of interest in and about the city at 10 a.m.

THURSDAY, 2.30 P.M.

Reception of members and guests by President Taft in the East Room of the White House.

THURSDAY, 8.15 P.M.

Address, "The Engineer in the Navy," by Rear-Admiral Geo. W. Melville, Retired.

Address, "Rear-Admiral Melville's Service to the Engineering Profession and to the Nation," and presentation to the historical series of paintings in the National Museum of a portrait of Rear-Admiral Melville; by Walter M. McFarland of Pittsburg, Pa. Acceptance of the portrait by Dr. C. D. Walcott, representing the Nation.

Ladies are specially invited.

Friday, May 7

PROFESSIONAL SESSION, 9.15 A. M.

Small Steam Turbines, Geo. A. Orrok.

Oil Well Tests, Edmund M. Ivens.

Safety Valve Discussion, Continued from the February meeting in New York.

Specific Volume of Saturated Steam,[1] Prof. C. H. Peabody.

Some Properties of Steam,[1] Prof. R. C. H. Heck.

A New Departure in Flexible Staybolts,[1] H. V. Wille.

Trips for the ladies to points of interest in and about the city at 10 a.m.

FRIDAY AFTERNOON

Trip by boat to Mount Vernon.

LOCAL COMMITTEE

Walter A. McFarland, *Chairman*

Gustav Ayres
Albert H. Buckler
Charles Eli Burgoon
Howard A. Coombs
James B. Dillard
William A. E. Doying
Charles E. Foster
H. A. Gillis
James Hamilton
Frederick E. Healy
Herman Hollerith
J. A. Holmes
Arthur E. Johnson
Frank B. King
Hervey S. Knight
Walter R. Metz
George L. Morton
Harold P. Norton
Willard L. Pollard
John E. Powell
Alfred H. Raynal
William B. Ridgely
W. E. Schoenborn
George R. Simpson
Charles F. Sponsler
Lucien N. Sullivan
William B. Upton
Charles V. C. Wheeler
Earl Wheeler

Committee of the Washington Society of Engineers

W. A. McFarland, Mem. Am. Soc. M. E., *Chairman*
A. E. Johnson, Mem. Am. Soc. M. E.
A. H. Raynal, Mem. Am. Soc. M. E.
W. E. Schoenborn, Mem. Am. Soc. M. E.
W. B. Upton, Mem. Am. Soc. M. E.
H. W. Fuller, Mem. Am. Inst. E. E.
John C. Hoyt, Mem. Am. Soc. C. E., Secretary, Washington Soc. Engrs.
D. S. Carll, Mem. Am. Soc. C. E., President, Washington Soc. Engrs.

Chairman of the Ladies Committee, Mrs. James Loring Lusk

THE UNIVERSITY CLUB OF WASHINGTON

The University Club of Washington, through Procter L. Dougherty, Chairman of the House Committee, has extended to the Society an invitation to make the club the headquarters for committee meetings, informal receptions, and a general bureau of information. The Society wishes to express its appreciation of this courtesy.

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[1] To be presented by title or in brief abstract.

CONVENTION NOTES

The reception of the members and guests by President Taft will be one of the pleasant functions of the convention.

The address by F. H. Newell, Director of the U. S. Reclamation Service, will be of extraordinary interest. Mr. Newell is in a position to command a large view of this important branch of the government's work of reclamation and the lecture will be illustrated by colored lantern slides showing marvelous transformations of arid regions into beautiful and fertile home-sustaining lands.

It is possible that during the convention there may be an ascension of a dirigible balloon and an aëroplane. If so, the Secretary of War, Mr. J. M. Dickinson, proposes, provided the conditions are favorable, to invite the members and guests. Those who attended the addresses on aëronautics at the time of the annual meeting, given through the courtesy of Brig-Gen. Allen, Major Geo. O. Squier and Lieut. Frank P. Lahm, and saw the wonderful moving pictures of dirigible balloons and aëroplanes in flight, will appreciate in a measure the opportunity of witnessing an actual ascension.

A very interesting feature will be two exhibition drills which will be given by the United States troops stationed at Fort Myer. These will be held in the open field or in the riding hall, according to the condition of the weather, so that in any event the convention guests may depend upon seeing the drill in comfort.

On Thursday evening, the address by Past-President Geo. W. Melville, Rear-Admiral, Retired, and former Engineer-in-Chief of the Navy, on "The Engineer in the Navy," will undoubtedly prove highly interesting, as Rear-Admiral Melville is a noted speaker. Upon this occasion there will be presented to the historical series of paintings in the National Museum a portrait of Rear-Adm. Melville, painted by Sigismond de Ivanowski. It will be received for the Nation by Dr. Chas. D. Walcott, Secretary of the Smithsonian Institution. The portrait is presented by friends and admirers of Rear-Admiral Melville.

It is unnecessary to emphasize the pleasure and instruction of visiting the places of interest in Washington. That Congress will be in session at that time is an added attraction.

HOTEL ACCOMMODATIONS

Members should bear in mind that Congress will be in session at the time of the convention, and also that this is the most delightful season of the year in Washington. As a result the city has many visitors and a consequent large demand on its hotel accommodations. Members expecting to attend the convention should engage rooms immediately.

The letter from the hotel assigning rooms should be preserved, and presented at the time the rooms are demanded. Two days before arriving in Washington, the hotel should be notified of the exact time of expected arrival, referring to the letter engaging rooms. If one hotel cannot provide satisfactory accommodations, immediate correspondence with others will doubtless secure what is desired.

Hotel Rates for Spring Meeting at Washington
Minimum Rates

	American Plan				European Plan			
	WITHOUT BATH		WITH BATH		WITHOUT BATH		WITH BATH	
	Single Room	Double Room	Single Room	Double Room	Single Room	Double Room	Single Room	Double Room
New Willard					$2.50	$4.00	$3.50	$5.00
Shoreham	$5.00	$9.00	$5.50	$10.00	2.50	4.00	3.00	5.00
Arlington	5.00	10.00	7.00	12.00	2.00	4.00	4.00	6.00
Raleigh					2.00	3.00	3.00	4.00
Ebbitt	2.50	5.00	4.50	7.00				
St. James					1.50	2.00	2.50	3.50
Cochran	4.00	7.00	4.50	9.00				
Riggs	3.00	6.00	4.00	8.00				
Normandy	3.50	6.00	4.00	9.00	1.50	3.00	3.00	4.00

If baggage is to be sent by express, checks can be given the baggage expressman immediately upon arrival. Trolleys leave the station for all hotels. Automobile passengers are allowed only a very small steamer trunk; carriage passengers, one medium-sized trunk. Extra baggage can be managed by taking as many carriages as there are trunks, or by sending some pieces by baggage express. The traveler wishing an automobile or carriage should give his checks to the uniformed porter immediately upon arrival as no carriages will be assigned to travelers until their baggage has first been brought to the platform in front of the station.

RAILROAD TRANSPORTATION NOTICE

Arrangements for hotel, transportation and Pullman car accommodations should be made personally.

Special concessions have been secured for members and guests attending the Spring Meeting in Washington, May 4–7, 1909.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a Buy your ticket at full fare for the going journey, between April 30 and May 6 inclusive. At the same time request a certificate, *not a receipt.* This ticket and certificate should be secured at least half an hour before the departure of the train.

b Certificates are not kept at all stations. Find out from your station agent whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.

c On arrival at the meeting, present your certificate to S. Edgar Whitaker, office manager at the Headquarters. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after May 7.

d An agent of the Trunk Line Association will validate certificates May 5, 6 and 7. No refund of fare will be made on account of failure to have certificate validated.

e One hundred certificates must be presented for validation before the plan is operative. This makes it important to ask for certificate, and to turn it in at Headquarters. Even though you may not use it this will help others to secure the reduced rate.

f If certificate is validated, a return ticket to destination can be purchased, up to May 11, on the same route over which the purchaser came, at three-fifths the rate.

This special rate is granted only for the following:

The Trunk Line Association:

All of New York east of a line running from Buffalo to Salamanca, all of Pennsylvania east of the Ohio River, all of New Jersey, Delaware and Maryland; also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville, and Washington, D. C.

The Central Passenger Association:

The portion of Illinois south of a line from Chicago through Peoria to Keokuk and east of the Mississippi River, the States of Indiana, and Ohio, the portion of Pennsylvania and New York north and west of the Ohio River, Salamanca and Buffalo, and that portion of Michigan between Lakes Michigan and Huron.

The New England Passenger Association, except via Bangor and Aroostook R. R., Rutland R. R., N. Y. O. & W. R. R., Eastern Steamship Co. and Metropolitan Steamship Co.:

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.

The Western Passenger Association offer revised one-way fares to Chicago, Peoria and St. Louis; these three places are points in the Central Passenger Association, and from these points travellers should purchase round trip tickets, in the manner outlined in the preceding paragraphs:

North Dakota, South Dakota, Nebraska, Kansas, Colorado east of a north and south line through Denver, Iowa, Minnesota, Wisconsin, Missouri north of a line through Kansas, Jefferson City and St. Louis, Illinois north of a line from Chicago through Peoria to Keokuk.

The Eastern Canadian Passenger Association:

Canadian territory east of and including Port Arthur, Sault Ste. Marie, Sarnia and Windsor, Ont.

TRAIN SCHEDULES

The following trains are suggested, via Pennsylvania Railroad.

Lv. New York, Tuesday, May 4	10.55 a.m.
Lv. North Philadelphia	1.00 p.m.
Lv. Baltimore	3.12 p.m.
Ar. Washington	4.15 p.m.

Lv. New York, Wednesday, May 5	12.10 a.m.
Lv. Baltimore	6.01 a.m.
Ar. Washington, Wednesday, May 5	7.12 a.m.

Lv. St. Louis, Monday, May 3	12.45 p.m.
Lv. Chicago	3.15 p.m.
Lv. Indianapolis	7.20 p.m.
Lv. Detroit	8.05 p.m.
Lv. Cincinnati	9.00 p.m.
Lv. Cleveland	11.30 p.m.
Lv. Columbus, Tuesday, May 4	12.45 a.m.
Lv. Pittsburg	7.30 a.m.
Lv. Baltimore	5.15 p.m.
Ar. Washington	6.22 p.m.

GENERAL NOTES

C. J. H. Woodbury, Mem. Amer. Soc. M. E., was appointed Honorary Vice-President to represent the Society at the annual meeting of the National Conference on Standard Electrical Rules held March 26.

HOTEL ACCOMMODATIONS

We wish to urge again the importance of definitely engaging rooms at the hotels in Washington well in advance of the Spring Meeting. Congress will be in session and Washington will have many visitors, so that the capacity of the hotels will be severely taxed. Members should make their reservations as early as possible and so secure comfortable accommodations.

STUDENT BRANCHES

The following Student Branches have been admitted to Affiliate Membership in The American Society of Mechanical Engineers:

Stevens Engineering Society; Polytechnic Institute Student Section; Armour Institute of Technology Section; Stanford Mechanical Engineering Association; Palo Alto Student Section; State Agricultural College of Oregon Student Section; Purdue University Student Section; University of Kansas Student Section; Cornell University Student Section.

DISTRIBUTION OF PAST ISSUES OF PROCEEDINGS

The Executive Committee of the Society has approved the reduction of the stock of past issues of the Proceedings with the exception of 50 copies of each number published previous to January 1907, and 75 copies of each number published during 1907.

After withholding these copies for the future demand, the balance of the stock, in accordance with the order of the Executive Committee, is to be distributed at the discretion of the Secretary among the Student Branches of the Society.

THE GAS POWER SECTION

The Gas Power Section during the last three months has been expanding its organization and development work. The Gas Power Membership Committee, with a largely increased personnel, has organized an auxiliary committee with members in the larger cities. Pamphlets and circulars illustrative of the purpose and activities of the Section have been prepared and circulated, and the Section membership shows a steadily increasing growth. In its work the committee has found many engineers eligible to membership in The American Society of Mechanical Engineers and proper membership blanks have been sent to them.

The Gas Power Meetings Committee has secured the following papers for the Washington Meeting:

Offsetting Cylinders in Single-Acting Engines, by Prof. T. M. Phetteplace (published in the February 1909 Journal).
A Method of Improving the Efficiency of Gas Engines, by Thos. E. Butterfield (published in the April 1909 Journal).
A Comparison of Steam and Gas Power for Marine Service, by C. L. Straub (published in this issue).
An Operating System for a Small Producer Gas Power Plant, by C. W. Obert (published in this issue).

The Gas Power Literature Committee has organized and is now at work. Arrangements are being made for the publication of the lists, abstracts and reviews so that they may be used to the best advantage of the profession.

The Gas Power Installations Committee has been busy preparing the forms for use in obtaining and recording the particulars of gas power installations. These forms will shortly be ready to go out and it is hoped that a partial report of the extent of the use of gas power may be ready for publication at the May Meeting.

The Gas Power Plant Operations Committee has organized and will devote its attention during the current year to representative plants from which full and accurate records may be obtained. Suitable forms will be prepared for the operating records of such plants and will be submitted to the Section for criticism. Several owners of gas power plants have asked the committee for copies of these forms in order that they may keep their own records in the best manner possible.

The stated meeting of the Gas Power Executive Committee was held at the Engineers' Club on the evening of April 6. On the invitation of Fred R. Low, Chairman of the Gas Power Section, the Executive Committee and the Chairmen of the Gas Power Committees dined together at the Engineers' Club just before the meeting. The discussion, which was informal, covered the scope and methods of work of the Section and many suggestions were made and discussed. The work of the various committees was taken up and coördinated. The Secretary reported the membership of the Section as follows:

A. S. M. E. Members registered	168
Affiliates	106
Total	274

Appropriations were requested to carry the work of the Section through the summer.

MEETING OF ST. LOUIS ENGINEERS

On Saturday evening, April 10, 1909, a meeting of the members of the Society residing in St. Louis and vicinity was called by Wm. H. Bryan. E. H. Ohle was appointed Secretary. The meeting was attended by about 20 engineers.

The following topics were discussed: *a* Local organization with occasional professional and social meetings; *b* Increase in membership; *c* Contributions to The Journal; *d* Making up a party to attend the coming Spring Meeting at Washington, May 4–7; *e* Extending an invitation to the Society to meet in St. Louis at some future time; *f* Other means of promoting the Society's welfare, not only locally, but generally.

M. L. Holman, Past-President of the Society, thought that the object of local organizations of The Am. Soc. M. E. should be the widening of the influence of the Society, emphasizing its national aspect.

Professor Hibbard said one of the most important objects should be to exert an influence upon the engineering schools, and to benefit the engineers by promoting discussion of problems.

All present expressed themselves in favor of a local organization. It was voted that a committee of three composed of the chairman and two others appointed by him should be formed to lay out a plan of organization and to report in 60 days.

THE ORGANIZATION OF A LOCAL SECTION OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Definite steps were taken at a meeting of 150 representative mechanical engineers of metropolitan Boston and nearby cities Friday evening April 16, for the organization of a local section of The American Society of Mechanical Engineers. The meeting was held in the auditorium of the Edison Building on Boylston street. This organization is made for the advancement of the local interests of the Society.

The movement started with an inquiry from a committee of the Boston Society of Civil Engineers as to the feasibility of forming a mechanical section of that Society. It soon became evident that a small proportion of the mechanical men in this vicinity are members of the Civil Engineers and it was decided to form a local section of The American Society of Mechanical Engineers of which there are about 350 members in the vicinity of Boston. The plan is, however, to maintain close relations with the local civil and other engineering societies.

A committee consisting of Prof. Ira N. Hollis, Prof. E. T. Miller and Messrs. Charles T. Main, I. E. Moultrop and Joseph W. Libby, members of this Society as well as of the Boston Society of Civil Engineers was chosen to arrange for future meetings and adopt such plans as are necessary for the development of the new local society.

The first meeting was addressed by Jesse M. Smith, President; Calvin W. Rice, Secretary, Fred R. Low, Chairman of the Gas Power Section, H. F. Bryant, Vice-President of the Boston Society of Civil Engineers, and several other men prominent in engineering circles.

THE BROOKLYN POLYTECHNIC STUDENT SECTION

The Brooklyn Polytechnic Student Section of the Society has organized under an Honorary Chairman, Prof. W. D. Ennis, Professor of Mechanical Engineering of the Polytechnic; a Chairman, James Russell; a Secretary, Percy Gianella; and a Governing Committee composed of James Russell, *Chairman*, Russell H. Brown, W. M. Sar Vant, and Percy Gianella.

The following committees have been selected: on Program, Chas. W. Gremple, *Chairman*, A. T. Smith, Vinton Smith, Alphonse A. Adler, W. J. Moore, Oskytel H. Clarke, F. Rhey Baldwin; on Admission, J. M. Wiley, *Chairman*, Clemente Hidalgo, W. E. W. Moore, Wesley M. Graff, Herman F. Weber, S. W. Berliner, Morgan L.

Woodruff; on Employment, M. G. Farrell, *Chairman*, Alfred Helwig, Wm. H. Brendlin. At the meeting April 3 the Committee on Admission proposed ten students for election, who were declared elected by the Governing Committee. The Committee on Employment reported that they had received communications stating that three positions were open to students, two as draftsmen, one collecting engineering material for a magazine.

THE JOINT CONSERVATION COMMITTEE

The work of conservation, until recently carried on by the Conservation Commission will now be advanced by the Joint Conservation Committee, of which the Hon. Gifford Pinchot is Chairman and Thomas R. Shipp is Secretary. The other members forming the Committee are: George C. Pardee, *California*; Knute Nelson, *Minnesota*; W. H. Milton, *Florida*; W. K. Kavanaugh, *Missouri*; Newton C. Blanchard, *Louisiana*; Paris Gilson, *Montana*: O. J. Salisbury, *Utah*.

THE PANAMA CANAL

J. Edward Simmons, president of the Chamber of Commerce, has appointed on the committee of seven to make a study, from the standpoint of the requirements of the world's shipping, of the problems involved in the construction of the canal at Panama. The committee appointed is composed of John R. Dunlap, Alfred P. Boller, Cornelius A. Pugsley, William L. Saunders, Mem. Am. Soc. M. E., Jacob W. Miller, Julio F. Sorzano, Mem. Am. Soc. M. E., and John D. Crimmins. The committee held its first meeting March 19.

NORTHWESTERN UNIVERSITY

On March 25 the Northwestern University at Evanston, Ill., inaugurated the Swift Hall of Engineering, a $100,000 building, presented by Edward F. Swift and his mother, Mrs. Gustavus F. Swift, of Chicago, together with $50,000 for maintenance. The University has organized a College of Engineering of which John Fillmore Hayford has been appointed Director. The engineering course offered will cover five years. At the end of the first four years the degree of Bachelor of Science will be conferred and the degree of Bachelor of Engineering will be given for an additional year of study. In general, the purpose underlying the instruction in this new college of engineering is to teach broad fundamental principles, devoting special attention to the cultural studies in the earlier years of the course, allowing students to specialize later.

At the dedication of the Engineering Building, which will take place May 7, Mr. Charles Whiting Baker, Mem. Am. Soc. M. E., and Editor of the *Engineering News,* will make the principal address which will be on a broader training for the engineer.

MEETING OF THE COUNCIL

The regular meeting of the Council was held April 13, 1909, in the rooms of the Society, the President, Jesse M. Smith, in the Chair. There were present: Messrs. Basford, Bond, Breckenridge, Carpenter, Gantt, Humphreys, Hutton, Moultrop and Swasey.

The following deaths were reported: Jasper R. Rand, and C. L. Hildreth.

The following resignations were reported: C. J. Carney, E. R. Behrend and Fred Collins.

The President reported the following committee appointments: *Finance,* George J. Roberts, in place of J. Waldo Smith, resigned; *Involute Gears,* Wilfred Lewis, Hugo Bilgram, Gaetano Lanza, Chas. R. Gabriel and C. W. MacCord; *Research,* R. C. Carpenter, James Christie, Charles B. Dudley, W. F. M. Goss and Richard H. Rice.

Voted: That the Secretary be instructed to procure art photographs of the past-presidents, an appropriation of $390 to be made for this purpose.

Amendments: The amendments to By-Laws 17, 27 and 28 were accepted subject to the approval of the Committee on the Constitution and By-Laws.

Resolved: That the amendment in the "Instructions for By-Laws" presented and recommended by the special committee of five (appointed at the joint meeting of the Standing Committees, called by the President to consider the relations of the Standing Committees to the appropriations for the work of the respective committees) be adopted, and that all present instructions conflicting therewith be and are hereby made null and void.

Resolved: That the Secretary be instructed to present to the Executive Committee a draft of such changes in the "standards" of the Society as may be necessary to bring them up to date, and to make them in complete harmony with action taken from time to time by the Council since the "standards" were established and adopted; and that these changes, when approved by the Executive Committee, shall be presented for adoption by the Council, as provided in the By-Laws.

STANDING COMMITTEES

Finance Committee: The following resolution was presented from the Finance Committee, and was adopted on motion:

Whereas, $2222.50 was raised as a special fund to take care of the entertainment expenses of the annual meeting,

Be it Resolved: That the Finance Committee recommend to the Council that the cost of entertainment at the annual meeting amounting to $2002.24, now charged to the appropriations of the Meetings Committee, be charged to this special fund, and the balance be held as a special fund for similar use at future meetings.

House Committee: The following record from the minutes of the House Committee was presented:

It was voted that the Committee adopt the plans and specifications prepared by the architect of the building the entire work to cost approximately $5400, and that the Committee instruct the Chairman to ask of the Council an appropriation of $2500 for this year, to be expended in a manner that the Committee may deem best in their judgment.

Resolved: That the Council approve the recommendation of the House Committee, including an appropriation of $2500 for these objects, to be expended as the House Committee may deem best.

Resolved: That the allocation of the charges for this work to operating and capital accounts be referred to the Finance Committee with power.

SPECIAL COMMITTEES

The Committee on Revision and Extension of the Code for Testing Gas Power Machinery, Chas. E. Lucke, *Chairman,* E. T. Adams, George H. Barrus, D. S. Jacobus, and Arthur West, made a general report and requested that they be discharged and a new committee appointed to revise, unify and standardize all the present codes of the Society on their various subjects. This report was received and the Committee discharged.

Voted: That nine members be appointed by the President, with the approval of the Council, a Committee on Power Tests, to revise the present testing codes of the Society relating to boilers, pumping engines, locomotives, steam engines in general, internal combustion engines, and apparatus and fuels therefor, and to extend these codes so as to apply to such power generating apparatus as the present codes do not cover, including water power, and bring them into harmony with each other and with the best practice of the day. This Committee may resolve itself into as many sub-committees as necessary, to coöperate with and report to the whole committee. That the committee be empowered to confer with the American Institute of Electrical Engineers, regarding electrical matters pertaining to the subject, and with any other engineering societies or organization which have formulated rules for similar tests, with a view to obtaining general coöperation of authorities in the proposed work.

Boiler Code: The committee, consisting of Messrs. Lieb and Taylor, appointed to investigate the advisability of a revision of the Standard Code on Steam Boiler Tests, reported that in their opinion it is desirable to undertake a revision of the Standard Code for Boiler Tests in view of the progress made in the art since the Standard Code was formulated.

The application of blast furnace gases, gas producer plants, oil fired furnaces and other important developments, make it desirable to bring the standard code up to date so as to include also provisions for gaseous and liquid as well as solid fuels. It may be desirable also in the revised code to give consideration to the question of a standard method for the sampling and testing of fuels.

The Committee on the Conduct of the Annual and Spring Meetings, F. R. Hutton, Ambrose Swasey and F. M. Whyte, reported that it recommends that the Meetings Committee be authorized in its discretion to contribute $300 toward the local expense of each semiannual meeting, such sums to include the expense of the meeting hall, and to be expended by the Local Committee provided for in R14. That in the annual meeting the cost of the President's Reception be borne by the Society and that the reception be open to all members and their guests. That in the case of both the Annual and Spring Meetings the Local Committee shall collect all the money for the social entertainment and disburse the same.

The Committee on The Journal, F. R. Hutton, George M. Basford and C. W. Rice, presented its report, which was duly accepted, specially endorsing the following principles: that the results should be attained within the income of The Journal, which should be self-supporting; and that net income therefrom, or so much of it as may be needed, should be kept available for its constant improvement.

The following resolutions were adopted and the Secretary requested to notify any committees affected by this action: The following By-Law was adopted and will be given its proper number.

THE JOURNAL

a

The Council shall institute a monthly publication to be called The Journal, which shall be under the management of the Secretary who shall act under the general supervision of the Publication Committee, subject to approval by the Council as to the policy thereof and the expenditures therefor.

b

Resolved: That By-Laws B25 relating to the duties of the Publication Committee be amended by adding in line 6 after the word "Society" the following sentence: "The Committee shall have the general supervision of the monthly publication of the Society known as 'The Journal.'"

c

Resolved: That the Council apportion under By-Law B21 to the Publication Committee of the Society, the work of general supervision of The Journal.

d

Resolved: That By-Law 23, relating to the duties of the Finance Committee, be amended by adding at the end:

"It shall have charge of the making of all contracts for printing in the Society's work, and the ordering of all expenditures thereunder."

e

Resolved: That under the provision of By-Law B21 the Council apportion to the Finance Committee the work of the supervision of all printing contracts for the Society's work, and that the Secretary, acting as Business Manager, carry out the directions of the Finance Committee therefor, as provided in that By-Law.

Voted: That the report of the Committee on The Journal be referred to the Publication and Finance Committees for report to the Council at its next meeting. It was the sense of the Council that the Publication Committee should enter immediately upon its duties of general supervision of the Journal without waiting for the formality of adoption of the by-laws involved.

Shop Section: The petition of certain members of the Society to form a Machine Shop Section was presented and referred to a special committee to consist of F. R. Hutton, *Chairman,* Alex. Humphreys, R. H. Fernald, H. H. Suplee, Fred W. Taylor (formerly Committee on Affiliated Societies) for report at the next meeting of the Council.

The Council adjourned to meet in Washington, Tuesday, May 4, at an hour to be determined later.

JOHN FRITZ MEDAL AWARD.

The John Fritz Medal, the only medal which the four National Engineering Societies confer, was presented to Charles T. Porter, Honorary Member of The American Society of Mechanical Engineers, on Tuesday evening, April 13. The presentation took place in the auditorium of the Engineering Societies building, 29 West 39th St., before distinguished invited guests and an audience representing the entire engineering profession. The medal was conferred upon Mr. Porter for his work in advancing the knowledge of steam engineering and for improvements in engine construction. Addresses were made by Dean W. F. M. Goss of the University of Illinois, upon The Debt of Modern Civilization to the Steam Engine as a Source of Power; by Prof. F. R. Hutton of Columbia University, Honorary Secretary of The American Society of Mechanical Engineers, on The Debt of the Modern Steam Engine to Charles T. Porter; by Robert W. Hunt, of Chicago, on The Debt of the Era of Steel to the High Speed Steam Engine; by Frank J. Sprague, of New York, on The Debt of the Era of Electricity to the High-Speed Steam Engine.

The John Fritz Medal was established by the professional associates of John Fritz of Bethlehem, Pa., in 1903, upon the occasion of his eightieth birthday, to perpetuate the memory of his achievements in industrial progress. Its award was placed under a Board consisting of four members from each of the four National Engineering Societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

Awards have been made to Lord Kelvin for his work in cable telegraphy and other scientific achievements; to George Westinghouse for the invention and development of the air brake; to Alexander Graham Bell for the invention and introduction of the telephone; to Thomas Alva Edison for his electrical inventions and developments.

Henry R. Towne, Past-President, Am. Soc. M. E., and Chairman of the Board of Award of the John Fritz Medal for 1909–1910, presided at the meeting, and in his opening remarks spoke briefly of the origin and history of the medal. He introduced Dean W. F. M. Goss of the University of Illinois, whose address preceded the presentation.

At the close of Professor Goss' address, Mr. Towne in a short introductory speech recalled that Mr. Porter is the third person and the first American to whom has been accorded the distinction of Honorary Membership in The American Society of Mechanical Engineers. On account of this relation, Mr. Porter was introduced by Jesse M. Smith, President of the Society. As the award was made by the Board of last year, under the chairmanship of E. Gybbon Spilsbury, the presentation was made by Mr. Spilsbury. Mr. Towne then introduced Mr. Smith, who said in introducing Mr. Porter:

The John Fritz Medal, established in 1902 by the American engineering profession as a meed of recognition for 'notable scientific or industrial achievement,' was awarded in the year 1908 by a board representing the four National Engineering Societies, to a distinguished mechanical engineer for 'his work in advancing the knowledge of steam-engineering and for improvements in engine construction.' I present to you, and to this company, the engineer to whom this high distinction has been granted.

He is honored because he saw the possibilities of the high-speed steam engine; because his mechanical genius in design made those possibilities real; and because he recognized the necessity for, and then applied, the very best mechanical construction to the realization of his ideals.

He then introduced into the development of the power plant, an idea and an influence so revolutionary as to make an epoch in the history of the art of engine building; and which has been as world-wide in its effects as the use of the reciprocating engine.

Many of the present generation of engineers have inherited, without effort and often without knowledge of their origin, the results which cost him many years of painstaking study and experiment to establish.

That he may receive the John Fritz Medal awarded to him, I now have the honor to present Charles Talbot Porter.

E. Gybbon Spilsbury, in presenting the medal to Mr. Porter, said:

Under instructions from the Board of Award of the John Fritz Medal, it is my privilege and pleasure to inform you that for your work in advancing the knowledge of steam engineering and for improvements in engine construction, you have been chosen as the worthy recipient of the medal for the year 1908–1909.

This medal was instituted in 1902 to commemorate the 80th anniversary of the successful and honored career of our beloved colleague John Fritz, and its award by a committee selected from the membership of the four great engineering societies of the United States is the highest honor which the engineering profession can onfer on any of its members.

Charles Talbot Porter, in the presence of this distinguished company, I now present you this medal, together with an engraved certificate of the award, and confer upon you all the rights and honors and the distinction which attach to this emblem. May you live long and happily to enjoy the appreciation which is your due at the hands of those you have so benefited by your work.

After the presentation, Mr. Towne read the following telegram from John Fritz:

"With all my heart regret my inability to be with my dear friends and associates this evening. I cannot be with you in person, but I will be with you in spirit. Please convey to my dear friend Porter my sincere congratulations and best wishes."

The addresses of the evening followed, abstracts of which are published in this report.

Professor Hutton read this congratulatory cablegram from Wm. H. Moore, Editor of *London Engineering:* "Heartiest congratulations to Porter," and a cablegram from the younger generation of Wm. A. Hoyle, with whom Mr. Porter was associated in his early work, which read: "All Hoyles congratulate Porter in our father's memory." The Iron and Steel Institute of Great Britain cabled: "The Iron and Steel Institute warmly approves of what has been awarded in recognizing the excellent work of Porter." From the Institution of Mechanical Engineers of Great Britain: "Goodwill and sympathy on the occasion of the presentation of the John Fritz Medal and congratulations to the recipient." From E. D. Leavett, Mem. Am. Soc. M. E., an early associate of Mr. Porter, a telegram of heartiest congratulations was received, and many other telegrams and cablegrams which were not read on account of lack of time.

In closing, Mr. Towne proposed a rising vote of good wishes for continued health, success and long life to the founder of the medal, John Fritz, and to the recipient, Charles T. Porter.

Abstracts of the several addresses here follow:

ADDRESS BY DEAN W. F. M. GOSS

Dean W. F. M. Goss spoke of the debt of modern civilization to the steam engine. Dreams of the possibilities of steam belong to the day of Addison, Steele, Swift and Defoe; days when there were brilliant men of letters; triumphs in architecture, achievements on the battlefield, but when there were no means for performing industrial work. There were no large factories in England because there was no way by which their machinery could be driven. Mines were abandoned because they were flooded with water, women and girls were toiling in the mines amid suffering and degradation. The movement of merchandise by land was laborious and travelling by sea slow and dangerous.

Into the midst of such conditions came the steam engine. It freed the mines of England from water, revived dormant industries, introduced new systems of manufacture, supplied power, water and effective means of sanitation to cities, supplemented in all these respects in later years by electric transmission for lighting, power and transportation. Steam usurped the place of wind in the propulsion of ships, and through the agency of the locomotive has carried civilization to the farthest ends of the earth. These achievements are direct contributions to the upbuilding of civilization, the key-note of which is service. The dwellers on the earth are beginning to see that if one nation suffers severely, all are likely to suffer in some degree and they are learning sympathy for their fellow-men.

ADDRESS BY PROF. F. R. HUTTON

It was assigned to Prof. F. R. Hutton to speak in detail of the debt which the reciprocating steam engine owes to the pioneer work of Mr. Porter. This debt may be grouped under five heads.

First, the reciprocating engine owes to him the first vision of the advantages that come from making the crank shaft turn at a high rate of revolution, whereby the weight of the motor per horse power is reduced. From this seed-thought has sprung the modern design of the motor for the self-propelled vehicle and for the aëroplane. The high speed involved the solution of difficult problems, owing to the necessity for starting and stopping heavy parts of the mechanism in each revolution.

The second debt is for Mr. Porter's recognition of these problems.

The third debt, perhaps the most important of all, is that the standard of mechanical construction in the high-speed engine must be of the highest type. We owe to Mr. Porter many manufacturing details which now are commonplaces of modern practice.

Fourth, Mr. Porter created a form of steam engine condenser to be attached directly to the engine and operated at a much higher rate of speed than that at which the ordinary pump could be used; and finally, invented a sensitive steam engine governor in two forms.

The address closed with a tribute to Prof. Chas. B. Richards, associated with Mr. Porter's early work of designing, and John F. Allen, who had conceived many details of the first high-speed engine which Mr. Porter combined into a harmonious whole.

ADDRESS OF ROBERT W. HUNT

Robert W. Hunt said it was scarcely conceivable that one could have witnessed in a single lifetime the remarkable development in the steel industry which he had observed since the birth of the Bessemer processes. These accomplishments were made practically possible by the application of a more rapid power. The early processes were deliberate because man was habituated to slow movements. The first power came from the slow-turning water wheel; later from the slow-speed steam engine. Faster movements were obtained through gears and belts. Among the first engineers to attach the rolling mill engine direct to its train of rolls were John and George Fritz, but the speed of their strokes was limited. Mr. Charles T. Porter was the first to give the rolling mill engineer a controllable direct-connected economical high-speed engine.

Mr. Hunt referred to two engines in a rolling mill plant in Troy, N. Y., in 1876. One set of rolls was driven by a walking beam low-pressure engine, taken from the steamboat Swallow, a Hudson River boat, and the other set was driven by Porter-Allen engines. The contrast between the steamboat engine with a slow speed of 35 or 40 r.p.m., and Mr. Porter's little engines, humming away at high speed, and accomplishing much greater results, was an educational sight.

ADDRESS OF FRANK J. SPRAGUE

Frank J. Sprague recalled that in 1867, at the French exhibition, Charles T. Porter installed two Porter-Allen engines, the only high-speed engines exhibited, to drive generators for supplying current for lighthouse apparatus. While these engines were not directly coupled, it is a curious fact that the piston speeds and revolutions were what is common today in isolated direct coupled plants. In the dozen years following, Mr. Porter built many engines with certain common characteristics, high piston speed and revolutions, solid engine bed and babbitted bearings, but there was no electric driving until 1880, when Mr. Porter installed a high-speed engine for Mr. Edison in his laboratory at Menlo Park. Shortly after this Mr. Porter was invited to construct for the Edison Station at Pearl Street, New York, the first of a series of engines for so-called steam dynamos, each independently driven by a direct coupled engine.

Mr. Sprague likened the relations of electricity and the high-speed engine, not to debtor and creditor, but rather to a close partnership, an industrial marriage, one of the most important in the engineering the world, that of prime mover and the electric generator. Here were two machines, destined to be joined together, economizing space, increasing economy, augmenting capacity, reducing investment, increasing dividends. Primarily, and largely due to Mr. Porter, the high speed possibilities of the engine were commercially demonstrated.

The following distinguished guests occupied seats on the platform:

Rear-Admiral Geo. W. Melville, John E. Sweet, C. A. Parsons, Jesse M. Smith, Charles T. Porter, Henry R. Towne, E. Gybbon Spilsbury, Prof. Chas. B. Richards, Jas. C. Brooks, Alfred Noble, Ambrose Swasey, Onward Bates, G. G. Ward, Chas. L. Clarke, W. H. Pegram, Prof. F. R. Hutton, Prof. W. F. M. Goss, R. W. Hunt, Frank J. Sprague, A. H. Pickler, C. Warren Hunt, S. S. Wheeler, E. Swennson.

MEMORIAL

ALFRED R. WOLFF

By Prof. J. E. Denton, Stevens Institute of Technology

Alfred R. Wolff, who died at his home in New York on January 7, 1909, was born in Hoboken, March 15, 1859. He entered the Stevens Institute of Technology with its class of 1876, when less than 14 years of age. He nevertheless easily carried the studies of the four years course, and was recognized as one of the leading students of a strong class.

His graduating thesis on windmills, which contributed original experimental data to the theory of the subject, was published through several numbers of the *Engineering and Mining Journal* of 1876, with favorable editorial comment. This thesis, supplemented by a compendium of modern American windmills, with tabular statements of their power and relative economy in practice, was published in 1885 by Wiley & Sons, in book form, under the title, The Wind Mill as a Prime Mover, and remains the only book on this subject.

After graduation, Mr. Wolff entered the office of the late C. E. Emory, then consulting steam engineer of New York and also consulting engineer to the U. S. Revenue Marine Service.

About 1880, Mr. Wolff decided to build up a practice as consulting engineer in New York. For about eight years his work consisted in the miscellaneous commissions of the steam expert. During this time he wrote several articles, among them a paper on The Value of the Study of the Mechanical Theory of Heat, presented at the first meeting of The American Society of Mechanical Engineers, of which he was a charter member; a series of editorial articles on steam and energy questions, which appeared in *The American Engineer,* with whose staff Mr. Wolff was connected for several years, and a supplement to Robert Briggs' essay on Steam Heating, published in the Van Nostrand Science Series.

In 1888 Mr. Wolff was engaged to assist the architect of the New York Freundschaft Club to complete its heating and ventilating plant. This engagement proved to be his opportunity to secure a lucrative specialty. At this time the architect depended for the design of the heating and ventilating plant upon the largely gratuitous plans and specifications of the prospective contractor and consequently the heating and ventilating requirements of a building were liable to be sacrificed in undue proportion to their importance. Obviously there was field for a middleman as the authorized agent of the architect.

In establishing himself in this field, Mr. Wolff encountered many difficulties which he overcame so successfully that at the end of six years he had referred to him more problems of heating and ventilating than he could execute. It was during this time that he wrote and published the pamphlet entitled The Ventilation of Buildings, an outline of the elements of physics, chemistry, and mechanics involved in the design of a heating and ventilating plant.

He introduced, from the German practice, in 1893, the "heat-unit system," under which the radiator surfaces for direct heating in a building are systematically calculated from the heat lost by the various thicknesses of walls and proportion of window surface. This was a substitute for the crude American rule, previously in vogue. allowing a square foot of radiator surface per various cubic feet of room contents, depending entirely on the judgment of the engineer.

He made popular the use of the combined plenum and exhaust system operating with "tempered" air, for ventilation, supplemented by direct radiators to supply the loss of heat by walls and windows[1] as a substitute for the "switch-damper" method of heating and ventilating formerly prevailing in the metropolitan district.

He introduced the thermostat in high-class residence work in 1893; and in 1902, he stimulated Johnson to apply this mechanism to the automatic control of humidity. This automatic "humidostat" was first successfully applied in the Carnegie residence.

Mr. Wolff introduced the use of the cheese-cloth filters, for straining the dust out of the air drawn into a building for indirect heating, into the metropolitan district in 1894, for use in the New York Life Building. He installed a heating and ventilating plant in the Board Room of the New York Stock Exchange in which the problems of constant temperature and constant hydrometric conditions were successfully met. The refrigerating feature of this plant is the only example of the artificial control of summer heat in an office building, and as such it is a unique monument to Mr. Wolff's ability.

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[1] Mr. Wolff illustrated the application of this combination together with the "heat unit system," in a lecture before the Franklin Institute in 1894, which was published in pamphlet form under the title The Heating of Large Buildings.

Mr. Wolff took part in the organizations of the Ethical Culture Society, especially in the maintenance of their charitable schemes. He was also an alumni trustee of the Stevens Institute of Technology from 1893 to 1896 and a permanent trustee after 1900.

Among a great many important buildings in which Mr. Wolff installed heating and ventilating plants are the following: Century Club; Waldorf-Astoria Hotel; Carnegie Music Hall; Lakewood Hotel, Lakewood, N. J.; United Charities Building; University of the City of New York; New York Herald Building; C. Vanderbilt residence; Teachers College; J. J. Astor residence; St. Regis Hotel; the Lying-in Hospital; Princeton Library; Brooklyn Institute; Columbia University; Sherry's Hotel; Delmonico's Hotel; University Club; Hotel Martinique; American Museum of Natural History; Cornell Medical College; Carnegie residence; Library of J. P. Morgan, Esq.; Hispanic Museum; Evening Post Building; Plaza Hotel.

NECROLOGY

A. KENNEDY ASHWORTH

A. Kennedy Ashworth, manager of the filter department and traveling engineer of the Pittsburg Gage and Supply Co., died January 20, 1909, at his home in Crafton, Pa. He was born May 26, 1873, in Covington, Ky., receiving his education in the schools of Pittsburg, Pa., and in the Cook Academy; he was also a graduate in Mechanical Engineering of Rose Polytechnic, and studied at the Western University of Pennsylvania.

He first entered the employ of the Joseph Horne Co. as mechanical engineer, and became chief engineer of their steam and electric plants. After about two years he became a member of the firm of D. Ashworth & Son, consulting engineers. He associated himself with the Pittsburg Gage and Supply Co., and was actively engaged in engineering work after that time, except for a short period when he was connected with the Buckeye Engine Co., establishing a Boston office. He also established offices for the Pittsburg Gage and Supply Co. in Philadelphia, New York, Chicago and other large cities.

He was a member of the Engineers' Society of Western Pennsylvania, the order of Free and Accepted Masons, and the Sons of the American Revolution, of Boston. He was formerly a member of the Shady Avenue Baptist Church, East End.

JASPER R. RAND

Jasper Raymond Rand, vice-president and director of the Ingersoll-Rand Co., New York, died in Salt Lake City, Utah, March 30, 1909. He was the son of Jasper Raymond Rand, one of the founders of the Rand Drill Co., and was born in Montclair, N. J., September 3, 1874.

He was graduated from Cornell University in 1898 with the degree of Mechanical Engineer, and served in Porto Rico in the Spanish-American war as a member of the 1st New York Volunteer Engineers. During 1899–1900 he was president of the Imperial Engine Co. at Painted Post, N. Y., which position he left to take the presidency of the Rand Drill Co. In 1905 he was elected vice-president and director of the Ingersoll-Rand Co., the position he held up to the time of his death.

Mr. Rand was a member of the Alpha Delta Phi Fraternity, the Spanish War Veterans, the American Institute of Mining Engineers, the Engineers' Club, the Cornell Club and the Alpha Delta Phi Club of New York.

CHARLES LEWIS HILDRETH

Charles Lewis Hildreth was born October 9, 1823, at Concord, N. H., and died suddenly on February 26, 1909, at Westford, Mass. He received his education at a private school in Nashua, N. H., and at the Appleton Academy in New Ipswich, N. H.

In 1845 he went to Lowell, Mass., and became an apprentice in the Lowell Machine Shop, which was incorporated the same year. After a service of three years, he became a contractor on piecework. He was identified for over fifty years with this company, being superintendent for twenty-six years. During the great depression of the iron trade in 1858 he went to Philadelphia and served as foreman in the Industrial Works. He returned to Lowell, Mass., in 1860, and assumed charge of the shop as general foreman, a position he held until 1879 when he was made superintendent of the entire plant. Mr. Hildreth was identified with the textile machinery trade during almost the entire period of its development in America.

In July 1905 he retired from business to his country home in Westford, Mass., where his death occurred.

He was president of the Mechanics Savings Bank in Lowell, Mass., was closely identified with the Lowell Textile School, and while in Lowell was an attendant at the Kirk Street Congregational Church; in Westford he attended the Union Congregational Church.

OTHER SOCIETIES

AMERICAN ELECTROCHEMICAL SOCIETY

The annual meeting of the American Electro-chemical Society will be held at the Clifton Hotel, Niagara Falls, Canada, on May 6, 7 and 8. A feature of special interest will be a symposium of papers on the electro-metallurgy of iron and steel. The whole first day, May 6, will be devoted to this subject. On the evening of Thursday the address of the retiring president, Dr. Edward G. Acheson, will be delivered.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION

The first session of the annual meeting of the American Railway Engineering and Maintenance of Way Association was held on Tuesday morning, March 16, at Chicago. After the president's annual address, reports of the various committees were submitted. The following officers for the ensuing year were elected:

President, William McNab; First Vice-President, L. C. Fritch; Second Vice-President, W. C. Cushing; Treasurer, W. S. Dawley; Secretary, E. H. Fritch; Members of Board of Directors, three years each, A. H. Rudd, A. W. Thompson.

PITTSBURG FOUNDRYMEN'S ASSOCIATION

At the April 5 meeting of the Pittsburg Foundrymen's Association, held at the Fort Pitt Hotel, Efficiency in Plant Organization and Operation was discussed. Harrington Emerson, Mem. Am. Soc. M. E., addressed the association on Modern Productive Relations between Shop Officials and their Subordinates and the Modern Theory of Profit Sharing. This was followed by an interesting discussion.

ST. LOUIS RAILWAY CLUB

At the April 9 meeting of the St. Louis Railway Club, H. Wade Hibbard, Mem. Am. Soc. M. E., Professor of Mechanical Engineering at the University of Missouri, presented a paper on Organization. There was a demonstration of autogenous welding by oxy-acetylen.

NEW ENGLAND STREET RAILWAY CLUB

On March 25 the New England Street Railway Club held its annual meeting and banquet at the Hotel Somerset, Boston. W. D. Wright of Providence, R. I., was elected president. D. L. Prendergast of Boston was toastmaster. Among the speakers were James F. Shaw, J. F. Jackson and P. F. Sullivan.

NEW YORK RAILROAD CLUB

On March 19, the annual electrical night of the New York Railroad Club, the subjects generally discussed were, The Approaching Transfer of the Electrification Problem and Standardization. Those who participated were: William McClellan, Mem. Am. Soc. M. E.; Edwin B. Katte, Mem. Am. Soc. M. E.; Henry G. Stott, Mgr. Am. Soc. M. E.; C. L. de Muralt and N. W. Storer, of Pittsburg.

NEW YORK ELECTRICAL SOCIETY

A meeting of the New York Electrical Society was held at the New York Hippodrome, March 31. At the conclusion of the regular hippodrome performance the members assembled on the stage and were addressed by Arthur Williams on the Electrical Equipment of the Hippodrome.

PROVIDENCE ASSOCIATION OF MECHANICAL ENGINEERS

On Tuesday evening, March 23, at the Technical High School Hall, D. J. Butts of New York gave an address on Electric Drives before the Providence Association of Mechanical Engineers. The speaker explained the advantage of electricity over belting both as regards economy of power and freedom from fire hazard. After the lecture, Mr. Butts illustrated by means of lantern slides the application of motor drives to a great variety of machines.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

At the March 24 meeting of the Municipal Engineers of the City of New York, Herman W. Merkel, Chief Forester, New York Zoölogical Park, presented a paper on Some Interesting American Trees, which was illustrated by lantern slides.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The American Institute of Electrical Engineers devoted their meeting in New York April 16 to a discussion of Industrial Education. A paper was presented by Herman Schneider, Dean of the College of Engineering of the University of Cincinnati, treating of the Fundamental Principles of Industrial Education.

Mr. Schneider stated that the problem is, what industrial training should the public schools give. It is obviously impossible to train children in the public schools for all the trades which the industries of even a small town require, and who shall decide which are the more important trades, and how shall public support be obtained from all sources to support the training in these few trades? There is involved in the problem justice to the children and justice to the taxpayer.

Mr. Schneider offered as a solution of the problem a system of coöperation between schools and factories for the efficiency training and civic training of young people after they have found their work.

He advocates a coöperative system, where the technique or practice is taught in the shop, and the science underlying it is taught by skilled teachers. Mr. Schneider describes a coöperative school at Fitchburg, Mass., where the students are divided into groups which alternate every week—one-half being in the day school and the other half in the factories. The course in Fitchburg is of five years' duration, and at the end of that time the student has been taught the simple science underlying his trade, shop mathematics, and a certain amount of cultural work. In addition he has become a fair mechanic. The money earned every alternate week, and during full time in summer, supplies the simple wants of the children and enables them to go to school when otherwise they would have to become little breadwinners.

The directors of the American Institute of Electrical Engineers have made the following nominations for officers to be elected at the annual meeting in May: President, L. B. Stillwell, New York; Vice-Presidents, J. J. Carty, New York; Paul M. Lincoln, Mem. Am. Soc. M. E., Pittsburg; Paul Spencer, Philadelphia; Managers, A. W. Berresford, Milwaukee, W. S. Murray, New Haven, H. H. Norris, Ithaca, S. D. Sprong, New York; Treasurer, George A. Hamilton, New York; Secretary, Ralph W. Pope, New York.

BOSTON SOCIETY OF CIVIL ENGINEERS

The annual meeting of the Boston Society of Civil Engineers was held at the house of the Boston City Club on Wednesday, March 17. The reports of the officers and the various committees were submitted at the business meeting, after which Pres. J. R. Worcester delivered his annual address. The officers elected for the coming year are as follows: President, Geo. B. Francis; Vice-President, Charles T. Main, Mem. Am. Soc. M. E.; Secretary, S. Everett Tinkham; Treasurer, W. S. Johnson; Librarian, Fred. I. Winslow; Director, Fred. H. Fay.

BROOKLYN ENGINEERS' CLUB

At the meeting of the Brooklyn Engineers' Club held April 8, J. E. Jennings presented a paper entitled Steel Transmission Towers, illustrated by lantern slides, in which he discussed their design, tests, shopwork and galvanizing, shipping and erection.

ENGINEERS' CLUB OF PHILADELPHIA

At the April 3 meeting of the Engineers' Club of Philadelphia, A. Fred Collins presented a paper entitled, Wireless Telegraphing and Telephoning. The paper consisted of a demonstration of certain forms of apparatus used in this connection. The Junior Section of the club met on the evening of April 12. The paper of the evening was Mining and Prospecting, presented by A. B. Richmond. The April 17 meeting of the club was devoted to a paper on Interurban Railways, by Benjamin Franklin. This paper was illustrated by lantern slides.

MODERN SCIENCE CLUB

At its meeting April 6, in its club house, the Modern Science Club of Brooklyn was addressed by Chas. A. Lundell, of the Thompson-Bonney Co., who spoke on Electric Motor Design. The speaker touched upon the experiments of Faraday and Siemens, and talked of the theory underlying armature and field design, especially as regards the effects of the use of various grades of iron and steel in the field magnets and the armature core. He showed the derivation of the formulae used, and went through the computations for the design of a motor as an illustration of the principles explained.

PERSONALS

W. W. Atterbury, Mem. Am. Soc. M. E., has been made Fifth Vice-President of the Pennsylvania Railroad. He was formerly General Manager.

John Lord Bacon, Jun. Am. Soc. M. E., has accepted a position with R. P. Shields & Son, San Diego, Cal., as Engineer and Superintendent of Construction. Mr. Bacon is the author of a book recently published, Forging: A Manual of Instruction in Hammering, Working, Forming and Tempering of Iron and Steel.

William A. Baehr, Mem. Am. Soc. M. E., until recently associated with the Laclede Gas Light Co., St. Louis, Mo., as Chief Engineer, has opened a consulting engineering business with an office in the Commercial National Bank Building, Chicago, Ill.

Ervin G. Bailey, Jun. Am. Soc. M. E., formerly Chief of Coal Department of the Arthur D. Little Laboratory, Boston, Mass., has resigned and organized the Fuel Testing Co., 220 Devonshire St., Boston. Associated with him is W. B. Calkins, formerly Chief Chemist of Laclede Gas Light Co., St. Louis, Mo.

C. Kemble Baldwin, Mem. Am. Soc. M. E., is the author of The Belt Conveyor in Railway Building, which appeared in the March 26 number of *The Railroad Age Gazette.*

An article on Tube Tiles used to Form Furnace Roofs, by A. Bement, Mem. Am. Soc. M. E., appeared in the April 6 number of *Power and the Engineer*. Mr. Bement presented a paper on The Illinois Coal Field before the April 7 meeting of the Western Society of Engineers.

Louis Bendit, Assoc. Am. Soc. M. E., formerly Sales Manager of Weber Gas Engine Co., Kansas City, Mo., has recently been appointed by the Buckeye Engine Co., Salem, Ohio, to take charge of their Kansas City office.

J. A. Bennett, Mem. Am. Soc. M. E., of Hartford, Conn., has accepted a position as Mechanical Engineer with the Lodge & Shipley Machine Tool Co., Cincinnati, O.

Prof. L. P. Breckenridge, Vice-President, Am. Soc. M. E., is the author of The Development of the Illinois Experiment Station, which appeared in the April 8 issue of *Engineering News*.

William H. Bryan, Mem. Am. Soc. M. E., delivered an address before the Department of Arts and Sciences of Washington University, St. Louis, Mo., February 12, the subject being The Mechanical Engineer, his Duties, Responsibilities and Opportunities.

W. E. Crane, Mem. Am. Soc. M. E., has contributed an article on Standpipes for a Water Power Supply to the April 6 number of *Power and the Engineer.*

Geo. H. Cushing, Mem. Am. Soc. M. E., is the author of Boiler Firing that Saves Coal, in the April 9 issue of *The Canadian Manufacturer.*

Prof. Wm. F. Durand, Mem. Am. Soc. M. E., has just published the second edition of his book on The Resistance and Propulsion of Ships.

Thomas C. Eayrs, Jun. Am. Soc. M. E., formerly located at Glenbrook, Conn., is now in the employ of the Westinghouse Electric and Manufacturing Co., Cincinnati, O.

Belting Compared with Chain Transmission, presented before the Leather Belting Manufacturers Association, February 1, by Harrington Emerson, Mem. Am. Soc. M. E., was published in the April 6 issue of *Power and the Engineer.* Mr. Emerson addressed the April 5 meeting of the Pittsburg Foundrymen's Association on Modern Productive Relations between Shop Officials and their Subordinates, and The Modern Theory of Profit Sharing.

Prof. R. H. Fernald, Mem. Am. Soc. M. E., of the Case School of Applied Science, delivered a lecture on Producer Gas before the Milwaukee Engineers, Society, March 25.

Fred. B. Franks, Mem. Am. Soc. M. E., recently resigned his position as General Superintendent and Chief Mechanical Engineer of the Bath Portland Cement Co.

Jos. Leon Gobeille, Mem. Am. Soc. M. E., until recently Superintendent of the Pattern Department, Abram Cox Stove Co., Philadelphia, Pa., has become Proprietor of the Gobeille-Harris Pattern Co., Niagara Falls, N. Y.

Harris R. Greene, Assoc. Am. Soc. M. E., formerly with the Parson Mfg. Co., New York, has accepted a position with the Alberger Condenser Co., New York, as Sales Engineer.

Edwin Jos. Haddock, Mem. Am. Soc. M. E., has opened offices in the Schultz Building, Columbus, Ohio, to engage in the general practice of engineering. He was formerly Chief Engineer of the Chain Department of the Jeffrey Mfg. Co., of Columbus.

The name of Sir Robert A. Hadfield, Mem. Am. Soc. M. E., appears in the list of fifteen candidates recommended for election as fellows of the Royal Society for 1909. Sir Robert is expected to visit the United States within the next few weeks.

Robert E. Hall, Mem. Am. Soc. M. E., until recently Secretary of the New York Steam Fitting Co., New York, has become Assistant to the Vice-President of Francis Bros. & Jellet, Inc., Philadelphia, Pa.

Orla K. Harlan, Jun. Am. Soc. M. E., formerly with the Lackawanna Railroad Co., Scranton, Pa., is now in the department of engineering and construction and in the mechanical division, Isthmian Canal Commission, Culebra, Canal Zone, Panama.

Prof. H. Wade Hibbard, Mem. Am. Soc. M. E., presented a paper on Organization, at the April 9 meeting of the St. Louis Railway Club.

George O. Hodge, Jun. Am. Soc. M. E., is now connected with the Bristol Engineering Corporation, Bristol, Conn.

F. W. Hollmann, Jun. Am. Soc. M. E., is the author of An Analysis of Steam and Inertia Forces, which was published in the April 6 issue of *Power and the Engineer*.

J. E. Johnson, Jr., Mem. Am. Soc. M. E., has resigned his position as General Manager of the Princess Furnace Co., Glen Wilton, Va.

Forrest R. Jones, Mem. Am. Soc. M. E., has published a book on The Gas Engine.

Robert R. Keith, Jun. Am. Soc. M. E., recently Superintendent and Assistant Manager for the Light Feed Oil Pump Co., has resigned to accept a position with the A. O. Smith Co. of Milwaukee, Wis., as Assistant Superintendent.

Sidney G. Koon, Jun. Am. Soc. M. E., until recently editor of *International Marine Engineering*, has associated himself with the Jones & Laughlin Steel Co.

Fred. A. Krehbiel, Assoc. Am. Soc. M. E., is no longer associated with the Arnold Co., Chicago, Ill., as Mechanical Engineer. He has accepted a similar position with the Fuel Engineering Co., of Chicago.

Henry A. Lardner, Mem. Am. Soc. M. E., has been made Manager of the branch office of J. G. White & Co., Inc., with an office in the Alaska-Commercial Building, San Francisco, Cal. He was formerly connected with the New York office of this company as General Manager of Engineering.

Paul M. Lincoln, Mem. Am. Soc. M. E., has been elected one of the vice-presidents of the American Institute of Electrical Engineers.

Charles T. Main, Mem. Am. Soc. M. E., has been elected Vice-President of the Boston Society of Civil Engineers.

The second edition of Steam Boilers, by Prof. Edw. F. Miller, Mem. Am. Soc. M. E., and Prof. C. H. Peabody, has just appeared.

Elements of Machine Manufacture, by Fred J. Miller, Manager, Am. Soc. M. E., appeared in the April issue of *Machinery*.

George A. Orrok, Mem. Am. Soc. M. E., Secretary of the Gas Power Section, addressed the members of the Brooklyn Polytechnic Institute, March 6, on the development of the large gas engine in connection with blast furnace operation.

Henry E. Paine, Jun. Am. Soc. M. E., formerly Secretary and Treasurer of the Walter R. Horning Co., has recently become connected with Hughson & Merton, Inc., San Francisco, Cal., and will be in charge of a new department created to handle a number of accounts for Eastern manufacturers of electrical lines.

William N. Parsons, Mem. Am. Soc. M. E., formerly connected with the W. P. Davis Machine Co., Rochester, N. Y., has become Chief Draftsman of the Buffalo Bolt Co., at North Tonawanda, N. Y.

Jos. L. Pitkin, Assoc. Am. Soc. M. E., until recently with the Lane Mills, New Orleans, La., is at present the Southern representative of A. Klipstein & Co., New York, with an office in Atlanta, Ga.

An article on Machine Tools, by L. R. Pomeroy, Assoc. Am. Soc. M. E., was published in the April issue of *The American Engineer and Railroad Journal.*

H. F. J. Porter, Mem. Am. Soc. M. E., has been giving during the winter a course of lectures in the School of Commerce and Finance of New York University. He has also delivered two lectures in the Graduate School of Business Administration at Harvard University. An article by him on The Employer, the Employee and the Community is published in the first number of the new magazine, *Industrial Engineering,* which has just appeared.

Samuel W. Powel, Mem. Am. Soc. M. E., Assistant Mechanical Engineer, American Radiator Co., has been transferred from the Buffalo to the Chicago office.

W. P. Pressinger, Assoc. Am. Soc. M. E., who recently resigned as General Manager of the Compressor Department of the Chicago Pneumatic Tool Co., has organized the W. P. Pressinger Co., to handle vacuum cleaning machines. The new company has opened offices and salesrooms at 1 W. 34th St., New York, and will establish local agencies at all distributing points throughout the Eastern territory.

An article by D. T. Randall, Mem. Am. Soc. M. E., on The Selection of Coal for Boiler Purposes, appeared in the April 6 number of *Power and the Engineer.* This paper was read at the Illinois Coal Conference, held March 10, 11 and 12.

Frederick Ray, Jun. Am. Soc. M. E., has contributed an article on Characteristics of the Turbine Pump to the March 23 issue of *Power and the Engineer.*

The second edition of a Text-book of Mechanical Drawing and Elementary Machine Design, by John S. Reid, Mem. Am. Soc. M. E., and David Reid, has recently been published.

A. G. Robb, Mem. Am. Soc. M. E., has contributed an article on Jigs and Fixtures for Connecting-rod Work to the April 15 issue of *The American Machinist.*

Robert W. Rogers, Jun. Am. Soc. M. E., formerly with Jason Bros., New York, is now with the Pioneer Publishing Co., New York.

Max Rotter, Mem. Am. Soc. M. E., delivered a lecture March 25, on Low-pressure Steam Turbines before the Engineering Society at West Allis, Wis.

David B. Rushmore, Mem. Am. Soc. M. E., addressed the April 2 meeting of the Pittsfield Section of the American Institute of Electrical Engineers on The Use of Electricity in the Steel Mills.

Theodore Stebbins, Mem. Am. Soc. M. E., who has recently resigned as General Manager of the Texas Traction Co., Dallas, was the principal speaker at a meeting and entertainment given last month to ex-President Charles W. Eliot of Harvard University, at the Agricultural and Mechanical College of Texas. The subject of Mr. Stebbins' address was Electric Railways.

William N. Stevens, Jun. Am. Soc. M. E., is no longer associated with Ford Bacon & Davis, New York. He has been appointed Vice-President of the Conveying Machinery Co., New York.

Wilson E. Symons, Mem. Am. Soc. M. E., has been appointed Superintendent of Motive Power and Machinery of the Chicago Great Western. For several years he has been President of the Pioneer Cast Steel Truck Co., Chicago, Ill.

An article on Milling Machine Tests, by Percy V. Vernon, Mem. Am. Soc. M. E., has been published in the March 16 number of *The Engineer*, London.

Charles E. Waddell, Mem. Am. Soc. M. E., will deliver a course of lectures before the Biltmore Forest School, Biltmore, N. C., on the subject of the application of the electric drive to woodworking machinery.

Thos. D. West, Mem. Am. Soc. M. E., has resigned the office of Vice-President and Secretary of the Thos. D. West Foundry Co., Sharpsville, Pa.

C. T. Wilkinson, Jun. Am. Soc. M. E., has contributed an article on The Hydroelectric Plant of the Schenectady Power Co., to the March 27 number of *The Electrical Review and Western Electrician.*

Reginald A. Wright, Mem. Am. Soc. M. E., has entered the service of the Philadelphia & Reading Coal and Iron Co., Pottsville, Pa., in the capacity of Chief Draftsman. Until recently he was associated with the Jenckes Machine Co., Sherbrooke, Que., as Chief Engineer.

THE SPECIFIC VOLUME OF SATURATED STEAM

By Prof. C. H. Peabody,[1] Boston, Mass.

Non-Member

For many years the specific volume of saturated steam has been computed from the thermodynamic equation

$$s = \frac{r}{AT} \cdot \frac{1}{\frac{dp}{dt}} + \sigma$$

in which the quantities have the following significance:

s is the specific volume, for example the volume in cubic meters of one kilogram.

r is the heat of vaporization in calories.

T is the absolute temperature obtained by adding 273 to the temperature by the centigrade thermometer.

$\frac{dp}{dt}$ is the differential coefficient of the pressure with regard to the temperature, the pressure being in kilograms per square meter.

σ is the specific volume of water (0.01 cubic meters per kg.

2 For this paper French units are used because the original data are given in them and comparison with experimental values is convenient.

3 All the quantities entering into this equation are now determined with a certainty and precision that must be considered satisfactory for engineering purposes and a comparison with experimental determinations of the specific volume shows an exceptionally good concordance.

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[1] Professor Naval Architecture and Marine Engineering, Mass. Inst. Tech.

To be presented at the Washington Meeting (May 1909) of The American Society of Mechanical Engineers. All papers are subject to revision.

4 To make the exposition of this statement clear it is necessary to review the experimental data and to state the precision that can properly be attributed to them.

5 The mechanical equivalent of heat as determined by Rowland[1] may be taken as 427 meter-kilograms (778 foot pounds) at 15 deg. cent., which corresponds nearly with 62 deg. fahr. There have been more recent investigations which on the whole confirm this result, though there is some indication that it is a trifle small. The uncertainty may be one in a thousand or one in two thousand.

6 Callendar[2] gives for the absolute temperature of freezing point 273.1 deg. cent., with a probable error of one in two thousand.

7 For the range of temperature from 30 deg. to 100 deg. Henning[3] gives the equation

$$v = 94.210\ (365 - t)^{0.31249}$$

in calories at 15 deg. cent. In English units the equation may be written

$$v = 141.124\ (689 - t)^{0.31249}$$

Experiments by Dieterici,[4] Griffiths[5] and A. C. Smith[6] confirm his results and extend the equation to freezing point. The probable error of this equation is one in one thousand.

8 In his paper, The Total Heat of Saturated Steam, read at the Annual Meeting, 1908, Dr. Harvey N. Davis gives for the total heat of steam from 212 deg. to 400 deg. fahr.

$$H = H_{212} + 0.3745\ (t - 212) - 0.000550\ (t - 212)^2$$

Transformed into French units this may be written

$$H = 638.9 + 0.3745\ (t - 100) - 0.00099\ (t - 100)^2$$

provided that the constant term be taken as the sum of Henning's value for r at 100 deg. cent. and the heat of the liquid be taken as 100.2, according to a consideration to be taken up later in this paper. To conform with the conditions already accepted, this equation should give the toal heat in calories at 15 deg. cent., while Dr. Davis used for the calories 1/100 of the heat required to raise one kilogram of water from freezing to boiling point. The difference amounts to 2/1000, as indicated by the heat of the liquid just mentioned ($q = 100.2$). Now the total heats at 100 deg. and 200 deg. cent. are 638.9 and 666.5, and their difference is 29.6 calories, so that the total effect is less than one-tenth of a calorie.

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[1] Proc. Am. Acad., vol. 15 (n.s. 7), 1879.

[2] Phil. Mag., Jan. 1903.

[3] Annalen der Physik, vol. 21, p. 849, 1906.

[4] Annalen der Physik, vol. 16, p. 912, 1905.

[5] Phil. Trans., 186, p. 261, 1895.

[6] Physical Review, vol. 25, 1907.

9 As for the heat of the liquid we have the three following sources of information:

a Barnes'[1] determinations of the specific heat of water from 0 deg. to 95 deg. cent.

b Dieterici's[2] determinations of the same property from freezing point to very high temperatures.

c Regnault's[3] determinations of the heat of the liquid.

Barnes' experiments were made by an electrical method for which great relative precision is claimed, and they showed a good concordance with Rowland's work on the mechanical equivalent, which in reality was an investigation also of the specific heat. Dieterici's investigation consisted essentially in heating water in a quartz tube, which was then transferred to the ice calorimeter. His results appear to be systematically larger than Barnes'; at 95 deg. cent., the discrepancy is $\frac{4}{10}$ of 1 per cent.

10 In 1907 the author endeavored to join Regnault's values for the heat of the liquid to those deduced from Barnes' values of the specific heat. Now Regnault's experiments consisted in running hot water into a calorimeter partly filled with cold water and noting the rise of temperature in the calorimeter. There were 40 tests in all, scattered irregularly from about 100 deg. to 190 deg. cent. for the temperature of the hot water; there were in a way three groups of tests, one near 110 deg., one near 160 deg., and the third near 190 deg. cent.

11 The average rise of temperature in the calorimeter for the first group was not far from 9 deg. cent., which item appears to account for the considerable irregularity of results at that place. The experiments with the highest temperatures had nearly twice that rise of temperature in the calorimeter and about half the dispersion of results.

12 In order to use Regnault's results his values for the heat of the liquid were recomputed, allowing for the true specific heat of the water in the calorimeter, and then a diagram was plotted as shown

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[1] Phys. Review, vol. 15, p. 71, 1902.

[2] Annalen der Physik, vol. 16, p. 593, 1905.

[3] Memoirs de l'Institut de France, vol. 26.

by Fig. 1, in which the abscissae are temperatures and the ordinates are values of $q - t$.

13 This allows of the use of a large vertical scale which much accentuates the apparent scattering of points. A curve was then drawn to join a curve from 0 deg. to 100 deg. cent., from Barnes' results for the specific heat of water. This curve passes near the highest group of points, above the middle group and below the lowest group.

14 It should be said that Barnes' results were first transformed to allow for the use of 62 deg. fahr. for the standard temperature, instead of 20 deg., which he had taken in his report; also that his values were slightly increased at temperatures approaching 100 deg. so as to avoid a break in the curve. The last had the effect of increasing the heat of the liquid at 100 deg. by one one-thousandth.

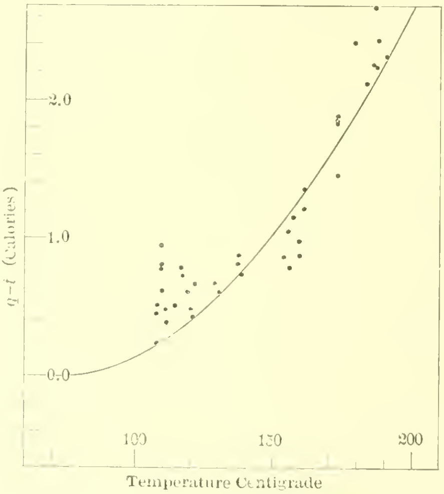

Fig. 1. Recomputation of Regnault's Experiments on the Heat of the Liquid of Water

15 Finally a table of specific heats was drawn off for temperatures from 0 deg. to 220 deg. cent., which served as the basis of a graphical integration for the value of $q - t$. Fig. 2 gives the curve representing the final value of this quantity and also a curve representing values that would be obtained if Dieterici's values for the specific heat were excepted.

16 The author is of the opinion that the full curve in Fig. 2 shows very nearly the true value of the property under consideration, and he has used it to determine heats of the liquid.

17 The maximum deviation of a single point from the curve in Fig. 1 is 0.8 of a calorie, which amounts to $\frac{3}{4}$ of 1 per cent of the heat of the liquid at that point. If we could consider that an error of 0.02 deg. might be attributed to the temperatures in the calorimeter it would account for one-third of that deviation. But to take the most pessimistic view of the situation and charge an error of 0.8 of a calorie against the method, we may still consider that for temperatures above boiling-point the heat of the liquid is always associated with the heat of vaporization, and that their sum is more than 630 calories, so that the deviation in this light amounts to $\frac{1}{8}$ of 1 per cent.

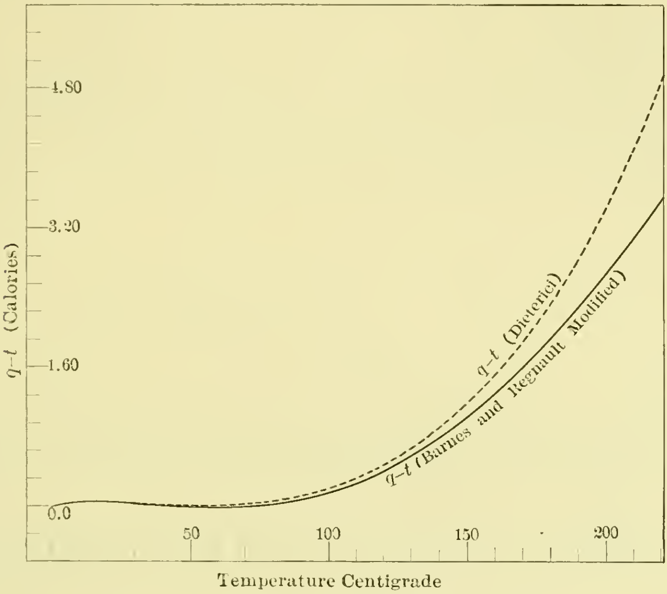

Fig. 2 Values of the Quantity ($q–t$)

THE FULL CURVE SHOWS THE QUANTITY DEDUCED FROM THE AUTHOR'S COMBINATION OF BARNES' EXPERIMENTS ON THE SPECIFIC HEAT OF WATER WITH REGNAULT'S EXPERIMENTS ON THE HEAT OF THE LIQUID, WHILE THE DOTTED CURVE SHOWS RESULTS FROM DIETERICI'S EXPERIMENTS ON THE SPECIFIC HEAT OF WATER.

18 A more just view is clearly to take the deviation of the worst group of points. This occurs at 117 deg. and is about 0.3 of a calorie, that is, 0.25 per cent of the heat of the liquid. The most favorable view is to consider that the upper end of the curve is well fixed by Regnault's experiments, which were then under the most favorable conditions, and that the lower end is tied to Barnes' values, which have all desired precision. This matter is discussed with some detail be-

cause the original experimental results needed to be entirely recast for the present purpose.

19 But while important from some aspects, the quantities with which we are dealing are not affected by uncertainties that concern our main investigation, i.e., the specific volume of saturated steam, for the maximum variation between the author's value for the heat of the liquid, and a value determined from Dieterici's investigation, amounts to 0.8 of a calorie at 200 deg. cent. This is only $\frac{1}{8}$ of 1 per cent of the total heat at that place. However, we need for our specific volume the heat of vaporization, and the discrepancy then becomes $\frac{1}{5}$ of 1 per cent.

20 Recent determinations of the pressure of saturated steam have been made by Holborn and Henning,[1] with all the resources of modern physical methods including the platinum thermometer. They claim a precision of 0.01 deg. in the determination of temperature and that their results reduced to the thermometric scale have a probable error of not more than 0.02 deg. at 200 deg. cent. Their own experiments cover the range of temperature from 50 deg. to 200 deg. cent. (122 deg. to 392 deg. fahr.), and they have extrapolated results to 205 deg. cent. Below 30 deg. they have made use of experiments by Thiesen and Scheel to extend results to freezing points; these experiments were not made with the same degree of precision as those by Holborn and Henning.

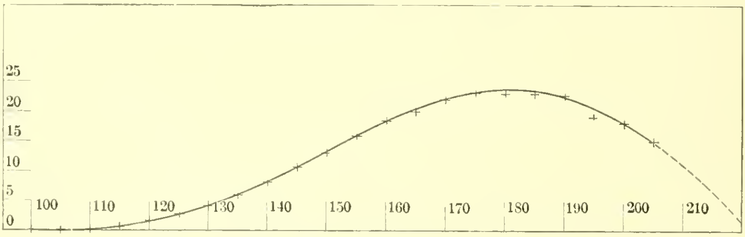

Fig. 3 Curve to Extrapolate Pressure of Saturated Steam to 220 Deg. Cent.

21 In order to extend calculations to 220 deg. cent., as has been the habit in computing steam tables, the author made use of a diagram shown by Fig. 3, in which the abscissae are temperatures centi-

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[1] Annalen der Physik, vol. 26, p. 383, 1908.

Note. Since these results may not be easily accessible, it may be of interest to say that they have been transferred directly to Table 3, of the author's Steam and Entropy Tables, edition of 1909.

grade and the ordinates are differences between Holborn and Henning's value and pressures computed by the following equation:

$$\log p = 5.457570 - 0.4120021\,(9.997411296 - 10)^{t-100} + (7.74168 - 10)\,(9.997411296 - 10)^{t-100}$$

which was chosen as a matter of convenience and because it gave a curve which crossed the axis near 220 deg. cent. when produced. It is thought that the extrapolated values are not much in error, though there is no means of determining this question. Fortunately this part of the range of temperature, as well as that below 30 deg. cent., is not so important to engineers.

22 The degree of precision attained by Holborn and Henning in the determination of the pressure of saturated steam is far beyond any direct technical requirement, since pressures are seldom determined closer than one-tenth of a pound; it is, however, requisite, if the differential coefficient $\frac{dp}{dt}$ is to be determined with certainty and accuracy.

23 Since their results are presented in a table without attempting to represent it by an equation, it becomes necessary to replace $\frac{dp}{dt}$ by $\frac{\Delta p}{\Delta t}$ which can be most readily obtained as follows: for a given temperature, for example 100 deg., we may compute the ratio by taking two adjacent temperatures, such as 98 deg. and 102 deg., finding the difference of pressure, which is to be divided by the difference of temperature; and the result is to be multiplied by 13.5959, because that is the pressure of one millimeter of mercury on one square meter. This result is

$$\frac{\Delta p}{\Delta t} = 13.5959\,\frac{815.9 - 707.3}{4} = 3691$$

24 A number of elements entered into the determination to use this method and to take an interval of 4 deg. If the relation of the pressure to the temperature could be represented by a second-degree curve, that is, if such a curve were a parabola with its axis parallel to the axis of pressure, the ratio $\frac{\Delta p}{\Delta t}$ for any interval would be precisely equal to $\frac{dp}{dt}$. A table of values that could be represented by such a curve would have constant second differences; by second differences are meant the results obtained by taking (*a*) the differences

of successive tabular values, and (*b*) the differences of these differences. An examination of the second differences of Holborn and Henning's values showed great regularity between 50 deg. and 100 deg., i.e., for their own determinations. The second differences increased slowly; for intervals of 4 deg. the increase was imperceptible, for 6-deg. intervals the increase was barely perceptible, but for 10-deg. intervals it was very apparent.

25 Now the possible precision of reading the height of a column of mercury, including allowance for variations of density, is better than the determination of temperature; consequently the probable error to be considered is that attributed to the determination of temperature, namely 0.01 deg., consequently the probable error of a single determination of the ratio $\frac{\Delta p}{\Delta t}$. To diminish the effect of local variations this ratio was computed for each degree of temperature and the regularity of the results thus obtained was tested by taking first and second differences. Where the second differences showed irregularity, the values of the ratio were changed to the extent of 1/1000 in order to improve the regularity of the second differences. This process is equivalent to drawing a smooth or fair curve to represent physical properties obtained by observation.

26 Having values of the ratio $\frac{\Delta p}{\Delta t}$ for each degree of temperature the specific volumes were computed by the thermodynamic equation in Par. 1. They were in turn tested for regularity by taking first and second differences: and again the values were changed when necessary to the extent of 1/1000 to improve the regularity of the second differences. The combined effect of both fairings is estimated not to exceed 1/500 in any case and the author believes that the probable error of the final determinations of the specific volumes is not greater than that amount for the range of 50 deg. to 200 deg. cent.

27 It may further be said that having computed the values of Apu at each fifth degree and plotted the results on a large diagram, no individual values were found to vary from a fair curve more than 1/750.

28 Fortunately there are extant experiments on the specific volume of saturated steam by Knoblauch, Linde and Klebe,[1] made with such a degree of precision as to give a satisfactory check on the computations made by the method described. These experiments

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[1] *Mitteilungen uber Forschungsarbeiten,* vol. 21, S. 33, 1905.

consisted in measuring the temperature and pressure of superheated steam at constant volume, and the results were so treated as to give the volume at saturation by a straight-line extrapolation with great certainty. The experimenters give the following equation to represent the properties of both superheated and saturated steam:

$$p\ v = BT - p\ (1 + a\ p) \left[C \left(\frac{373^3}{T} \right) - D \right]$$

$B = 47.10$; $a = 0.000002$; $C = 0.031$; $D = 0.0052$, volumes being in cubic meters per kilogram, pressures in kilograms per square meter, and the absolute temperature being on the centigrade scale.

29 For English units the equation may be written

$$p\ u = 85.85\ T - p\ (1 + 0.00000976\ p) \left[\frac{150{,}300{,}000}{T^3} - 0.0833 \right]$$

the volumes being in cubic feet, the pressures in pounds per square foot and the temperatures in degrees fahr.

30 Knoblauch claims for this equation a mean probable error of 1/500, though admitting individual discrepancies of twice that amount. This equation applied to the computation of specific volumes of saturated steam shows a good concordance with results, computed by the thermodynamic equation, the greatest discrepancy being 1/300 at 165 deg. cent. (329 deg. fahr.).

31 Not satisfied with this apparent concordance, which after all was with an empirical equation which on examination showed somewhat larger variation from individual experimental values at saturation, the author had a diagram drawn of the 32 values of the specific volume reported by the experimenters. The diagram was drawn to a very large scale, using temperatures for abscissae and logarithms of volumes for ordinates, and a fair curve was drawn by aid of a stiff spline. From readings on this curve the volumes were determined at 5 deg. intervals, and are set down in the accompanying table together with values computed by the thermodynamic equation.

32 The greatest deviation of values in this table is 0.2 per cent; which is precisely the probable error assigned by the experimenters for their work. It may therefore be concluded that between the limits of temperature in this table and probably from 30 deg. to 200 deg. cent. (86 deg. to 392 deg. fahr.), the probable error of computations by aid of the thermodynamic equation is not in excess of 1/500.

COMPARISON OF EXPERIMENTAL AND COMPUTED VALUES OF THE SPECIFIC VOLUME OF SATURATED STEAM

Temperature	Volume, Cubic Meters			Temperature	Volume, Cubic Meters		
	Experimental	Computed	Per cent deviation		Experimental	Computed	Per cent deviation
100	1.674	1.671	+0.18	145	0.4458	0.4457	+0.02
105	1.421	1.419	+0.14	150	0.3927	0.3921	+0.15
110	1.211	1.209	+0.17	155	0.3466	0.3463	+0.09
115	1.036	1.036	0.	160	0.3069	0.3063	+0.20
120	0.8894	0.8910	−0.18	165	0.2724	0.2729	+0.18
125	0.7688	0.7698	−0.13	170	0.2426	0.2423	+0.12
130	0.6670	0.6677	−0.10	175	0.2168	0.2164	+0.19
135	0.5809	0.5812	−0.05	180	0.1940	0.1941	−0.05
140	0.5080	0.5081	−0.02				

33 This conclusion carries with it the attribution of at least the same degree of precision to all the properties entering into the thermodynamic equation. A little consideration will show that this conclusion covers all the properties given in steam-tables including the entropy. As an apparent exception we have the heat of the liquid at high temperatures which may be uncertain to the extent of $\frac{1}{4}$ of 1 per cent of itself, but as that quantity is then associated with the heat of vaporization the influence of such an error will be of no consequence in computations.

34 It may therefore be expected that steam tables based on the present information will have permanence.

AUTOMATIC FEEDERS FOR HANDLING MATERIAL IN BULK

By C. Kemble Baldwin, Chicago, Ill.
Member of the Society

In the writer's paper on the Belt Conveyor, read before the Society in June, 1908, mention was made of the advisability of using some type of automatic feeder when feeding a conveyor from bulk, for example, from a storage bin. This brief mention of the automatic feeder brought so many inquiries for information regarding feeders for various materials that this paper has been prepared in order to present a brief description of the various types now in use. The cuts are not intended to show the construction, but to illustrate the principle involved, so that they may be compared.

2 Careful study of this subject reveals the fact, so common in engineering, that a particular type of feeder has been developed in a certain industry, or locality, and is little used elsewhere. The types illustrated and described below are only those which have come under the writer's personal observation in many processes and locations within the past fifteen years. There may, therefore, be many other types.

3 When handling dry, free-flowing material such as grain, from a storage bin to a conveyor, a feeder is not required, as a simple gate may be set to give the desired opening, thus allowing the proper quantity to flow from the bin. Should the material be of varying size, such as mine-run coal, a simple gate is not satisfactory unless constantly attended; even then it is impossible to get the same constant, regular feed that a properly designed feeder gives. If the gate is raised high enough to allow a large lump to pass, there usually results a rush of fine material, which floods the conveyor before the gate can be closed. The automatic feeder, therefore, not only saves the expense of an attendant, but insures a constant and regular feed, irrespective of the size of the material.

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[1] To be presented at the Washington Meeting (May, 1909) of the American Society of Mechanical Engineers. All papers are subject to revision.

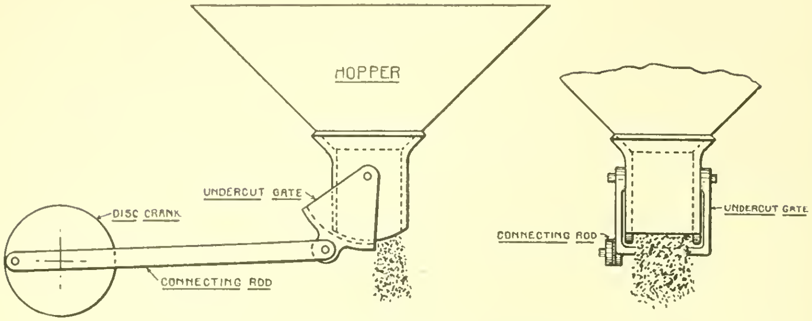

Fig. 1 Undercut-Gate Feeder

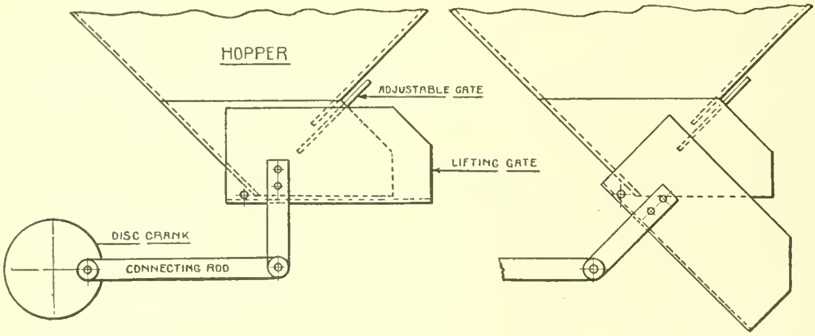

Fig. 2 Lifting-Gate Feeder

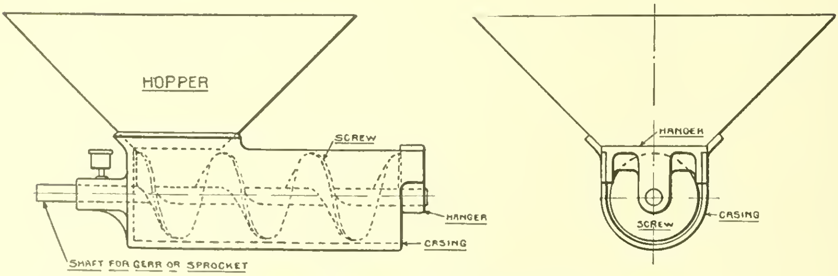

Fig. 3 Screw-Conveyor Feeder

4 Fig. 1 shows the undercut-gate feeder, with a body either of cast-iron or steel plate. Pivoted near the top is the undercut gate—which is swung back and forth by a connecting rod from crank or eccentric. This type of feeder is best adapted to fine-sized, free-flowing material. Material containing lumps is likely to bridge. As the feed is intermittent, the feeder is generally used in connection with chain or bucket conveyors, the strokes being timed to feed material between the flights, or into the buckets. The capacity may be changed only by changing the length or the number of strokes. As the length of stroke is more easily changed, it is preferable to use a crank rather than an eccentric, as in practice the quick return of the eccentric has not been found of sufficient value to offset the great advantage of a crank with an adjustable throw.

5 The lifting-gate feeder, shown in Fig. 2, also gives an intermittent feed and is therefore used only with a chain or bucket conveyor. The chute is hinged, so that when down, the material will flow out of the hopper, but when raised above the angle of flow of the material, the discharge is stopped. The moving of the chute may be accomplished by a connecting rod receiving motion from either crank or eccentric. This feeder will handle material regardless of size, but it must be free-flowing material, so that it will move by gravity when the chute is lowered to the angle of flow. The capacity may be adjusted by varying the number of strokes, also, in a measure, by increasing the length of the stroke, thus increasing the maximum angle of the chute and causing the material to flow more quickly.

6 The screw-conveyor feeder, illustrated in Fig. 3, will deliver a constant stream of material, but in this case also it must be of such a nature that it will flow by gravity to the screw. The capacity can be changed only by altering the speed of the screw shaft. This type of feeder has a large field in the handling of pulverized material, such as coal, cement, etc.

7 The roll feeder, shown in Fig. 4, is extensively used in the mineral industries for handling both large and small materials. The roll is so located under the hopper that the material will not flow when the roll is stationary, but when rotated it will carry the material forward. The capacity is determined by the speed and width of the roll, and the thickness of the stream, as fixed by the adjustable gate.

8 The roll feeder has been successfully used in handling iron-ore, coke and stone from the bins to the weigh cars for furnace changing. Edison used this type for feeding ore and stone from bins to crushing-rolls. The disadvantage is the head-room required, owing to

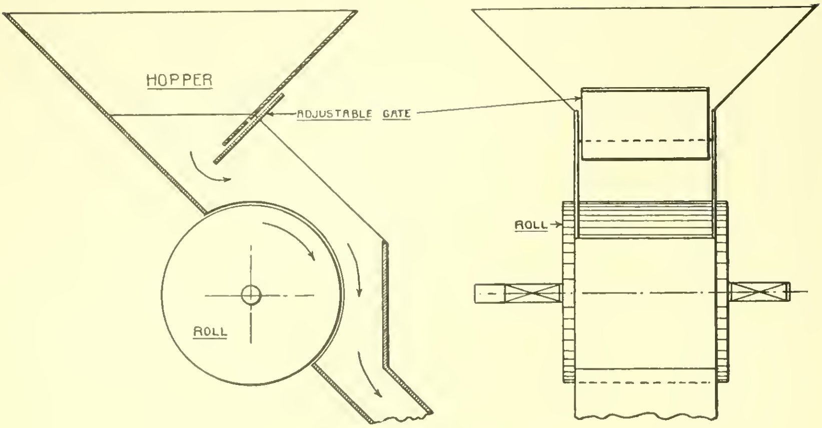

FIG. 4 ROLL FEEDER

the large roll necessary to satisfactory operation. For handling mine-run material, the roll should be 6 ft. to 8 ft. in diameter and in many cases it is not possible to obtain this space.

9 The rotary-paddle feeder, Fig. 5, acts not only as a feeder, but as a measuring device. It is used for fine material which flows readily from the blades. The capacity is fixed by the speed of the paddle shaft.

10 The revolving-plate feeder, shown in Fig. 6, is used mostly for feeding stamp-mills. The inclined plate driven by gears, placed either above (as shown) or below, moves the material out of the hopper

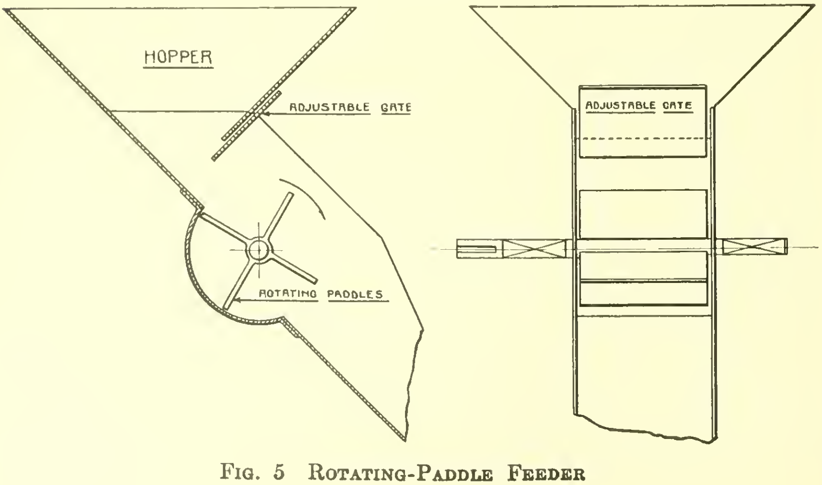

FIG. 5 ROTATING-PADDLE FEEDER

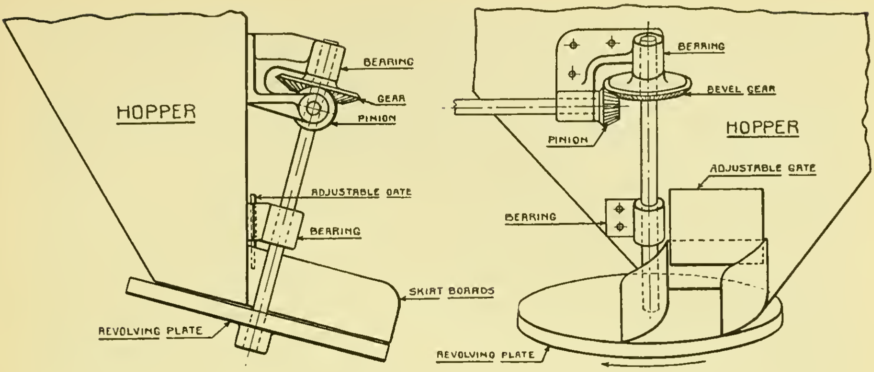

Fig. 6 Revolving-Plate Feeder

where it is scraped off by the skirt-board. When the skirt-board is made adjustable, sticky material may be handled by this feeder because the curved plate will scrape the material off the revolving disc and into the chute. The capacity is fixed by the speed of the plate and the location of the adjustable gate.

11 Fig. 7 illustrates the apron-conveyor feeder used for handling material of all sizes. The conveyor may be of any of the various types of apron flights, depending on the nature of the material handled. The chain should be provided with rollers or wheels traveling on

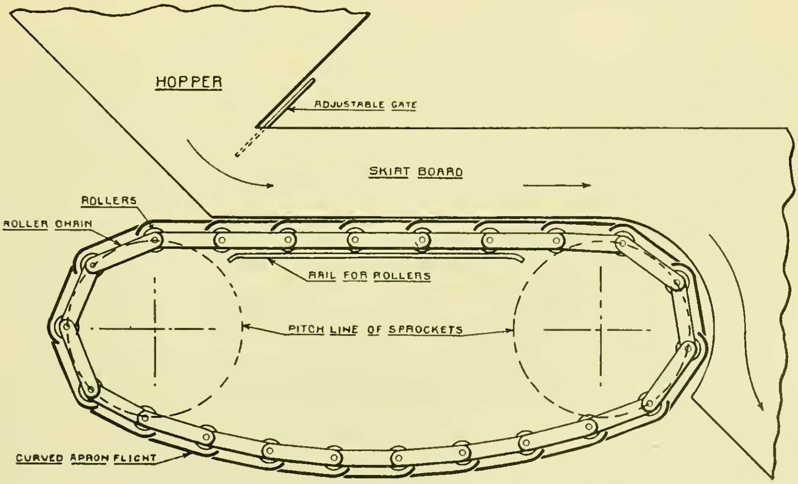

Fig. 7 Apron-Conveyor Feeder

track to prevent the apron from sagging. The capacity is fixed by the speed of the apron and the position of the adjustable gate.

12 The disadvantage of this type is the inherent disadvantage of the apron conveyor. Should the flights become bent or buckled, the material leaks through or catches between them. It has an advantage over other feeders in that it may be used to carry the material a greater distance.

13 A rubber or canvas belt may be used in place of the apron, in which case the belt is supported by idlers placed close together.

14 The swinging-plate feeder, shown in Fig. 8, is used for handling coal and such material of all sizes. It consists of two castings pivoted at their tops and swung alternately so as to move the material forward on the bottom plate. The plates are moved by connecting-rods from a crank or eccentric through a rocker shaft. The capacity is fixed by the length and the number of strokes, but as it is limited to the amount of material displaced by the plates, a wide range is not possible.

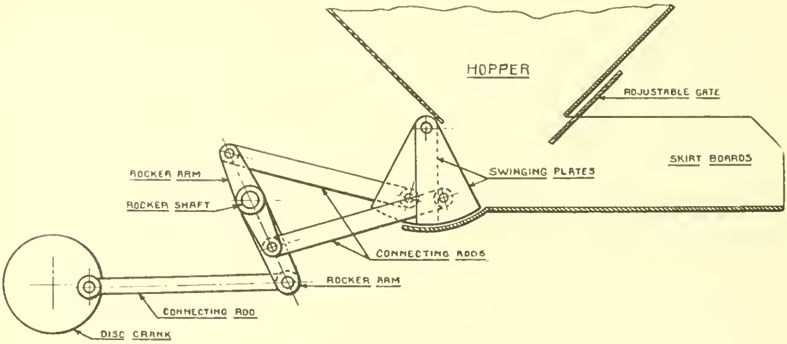

Fig. 8 Swinging-Plate Feeder

15 The disadvantages are the lack of adjustability and the tendency of the material to pack. It will also be noted that the feeder is not self-cleaning, so that the bottom plate always contains material which is very liable to freeze in winter.

16 The plunger feeder, illustrated in Fig. 9, is similar in operation to the swinging-plate feeder in pushing the material along the bottom plate. The plunger may be built either in one or two parts, moving ahead alternately and driven through a rocker shaft, as in the case of the one previously described. The capacity is fixed by the number and length of the strokes and the location of the adjusting gate.

This type has the same disadvantages as the swinging plate feeder, the most serious being that it is not self-cleaning.

17 Fig. 10 shows the reciprocating-plate feeder, consisting of a plate mounted on four wheels forming the bottom of the hopper. When the plate is moved forward, it carries the material with it, and when it is moved back the plate is withdrawn from under the material, allowing it to fall into the chute. The plate is moved by a connecting rod from crank or eccentric. The capacity is determined by the length and number of strokes and the location of the gate. The disadvantages are the lack of adjustment and the inability to clear the feeder of material.

18 The shaking feeder, Fig. 11, consists of the shaker-pan located under the opening in the bottom of the hopper at such an angle that the material will not flow when the pan is stationary. When given a reciprocating motion by the crank and connecting-rod, the material is moved forward on the pan. The front end of the pan is carried by a pair of flanged wheels; the back end is suspended by two hanger-rods, each being provided with a turn-buckle so that the angle of the pan may be varied. The crank having an adjustable length of stroke, there are three variables, viz: number of strokes, length of stroke, and inclination of the pan. As the number of strokes is difficult to change, and the others easily changed, the feeders are usually designed for about 75 strokes per min., a number determined by experiment. The angle of the pan is fixed by the capacity desired and the nature of the material handled. For coal, stone, ore, etc., 8 deg. to 10 deg. is sufficient, while clay and other sticky substances require from 15 deg. to 20 deg. The length of stroke varies from 4 in. to 12 in., so that a large range is possible.

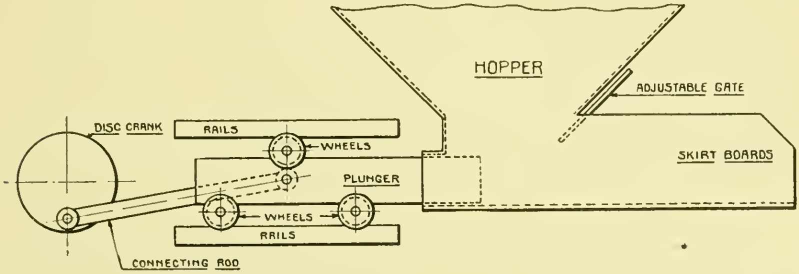

Fig. 9 Plunger Feeder

19 A feeder designed to handle 400 tons per hr. of mine-run coal

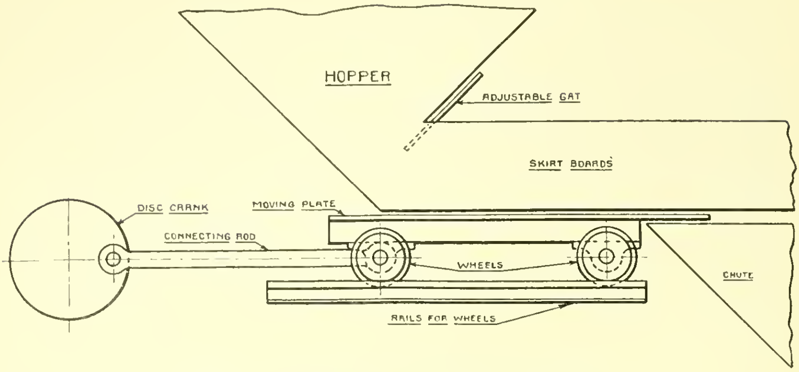

Fig. 10 Reciprocating-Plate Feeder

was changed in five minutes to deliver 30 tons per hr., by shortening the length of stroke and lowering the pan until nearly horizontal.

20 Not only has this feeder the widest possible range in capacity, but it is self-cleaning, a very important feature. From the cut it will be noted that the pan is placed under the opening and the material rests directly on the pan, so that when the pan is moved the material in the hopper is moved, which prevents the material from bridging.

21 The shaking feeder has none of the disadvantages of the other types for general use, and possesses many advantages which the others lack. Owing to its great flexibility it is more easily standardized

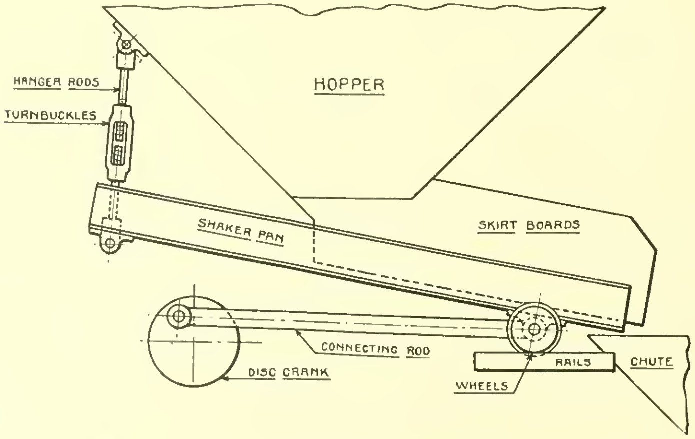

Fig. 11 Shaking Feeder

and will successfully handle practically any material, regardless of size or condition. If desired the bottom plate may be perforated to screen out the fine material thus acting as both screen and feeder. This is not possible with any of the other types.

22 The power required by all of the types is so small that it is not an important consideration. The shaking feeder mentioned above, which handled 400 tons of coal per hr., required but 3.5 h.p.

23 The preceding cuts and descriptions will give a general idea of the different types and their possible uses, so that an engineer may readily choose the best type for the work to be done. The point that should be kept in mind is, that it is always advisable to gear the feeder to the conveyor, crusher, or other machine which it feeds so that they will both start and stop simultaneously.

POLISHING METALS FOR EXAMINATION WITH THE MICROSCOPE

By Albert Kingsbury, Pittsburg, Pa.

Member of the Society

In 1902 the writer made experiments to find the most suitable method of polishing samples of metals for microscopic examination. The polishing of the surface is one of the most important as well as most troublesome details of metallography, particularly when high magnification is required.

2 At the outset, trials were made of all the methods of which descriptions have been published. Some of those methods have been successfully employed by various metallographists, as shown by numerous reproductions of excellent micro-photographs in different publications. Nevertheless the writer did not find any of these free from objectionable features. The ideal method should produce a fairly flat surface, free from excessive relief of the harder constituents, rounded edges at flaws, or scratches and smearing of the metal. The method should be simple, the materials employed readily available, and the process as rapid as consistent with the first-named requisites. None of the published methods embodied all these requisites, nor is a perfect method likely to be found. However, the method finally developed by the writer appears to him superior.

3 The preliminary trials were made with rotating discs covered with various materials, including canvas, felt, silk, leather, chamois, parchment, paper, wood, pitch, asphalt, resin, shellac, beeswax, etc. The polishing powders included commercial abrasives, such as emery, carborundum, tripoli, crocus and jewelers' rouge; also precipitates, such as carbonates and sulphates of the alkaline earths. Attempts were made to obtain fine finishing-powders by the levigation process from commercial abrasives. These abrasives were tried both wet and dry and with various speeds of the discs. Hand polishing was also tried.

To be presented at the Washington Meeting (May 1909) of The American Society of Mechanical Engineers. All papers are subject to revision.

It is needless to detail the objectionable features encountered, which are probably familiar to all metallographists.

4 The method finally adopted was the result of two distinct discoveries: (*a*), that ordinary paraffin wax makes a good polishing bed; (*b*), that excellent polishing-powders of certain grades are commercially available.

5 The paraffin is used as a facing for rotating discs of metal, preferably brass, about 8 in. in diameter. The discs are grooved on the flat face for anchoring the wax. To prepare the discs, they are warmed to about 100 deg. cent., and laid flat, and the melted paraffin is poured on them to a depth of about ½ in., a removable ring or band retaining the melted wax. The whole is then covered to exclude dust and allowed to cool. After the wax has solidified it may be dipped in water to hasten the hardening. Since the wax has very little viscosity when melted, all hard foreign particles, which might produce scratches in the samples, settle out before the wax hardens, the elimination being practically complete. No advantage in this respect was gained by keeping the wax in a fluid condition on the disc for several hours in an oven. After the hardening of the wax, the discs are placed on the spindle of the polishing machine and the face of the wax is turned true and flat by a hand-tool.

6 In the writer's machine the spindle was horizontal and four discs were used, for abrasives of progressive fineness, two discs being placed back to back at each end of the spindle. The disc used for the final polishing should not be perforated and the wax should be continuous to the center of the disc, as that part is best for the finishing touches to the sample. This latter disc should be at the right-hand end of the spindle. The speed of rotation should be about 200 r.p.m.; a higher speed throws off the polishing-powder with the water used, and a lower speed makes the work too slow. A stationary sheet-metal strip about 3 in. wide bent over the discs serves as a screen.

7 The polishing-powders, in the order used, were as follows: (*a*) commercial flour of emery; (*b*) washed Naxos emery, 3/0 grade; (*c*) washed Naxos emery, 7/0 grade; (*d*) soft optical rouge, light grade. these were obtained from the George Zucker Co., New York, except the first, which is available everywhere.

8 The emery powders were mixed to a paste with water in tall glass jars provided with covers; the paste was applied to the rotating discs with small brushes as required, the brushes being kept in the jars when not in use. The rouge was in cake form, best applied by holding a small piece in the hand, wetting both the rouge and the wax, and pressing the rouge lightly against the rotating surface.

9 A small quantity of water is required throughout the polishing process, but water cannot be used very freely without wasting the powders. The water is best applied as required, from an ordinary chemist's wash-bottle, held in the left hand while the right hand manipulates the sample. No water-pipes or drains are required for the polishing machine. Distilled water may be used if available. If tap-water is used, it should be drawn into large jars provided with covers and siphons, and allowed to stand a day or more before use, in order that all gritty particles in suspension may be deposited. The inner ends of the siphon tubes should be at least 3 in. above the bottom of the jars.

10 The treatment of the samples is as follows: the samples are first dressed to shape and size by any convenient method, the surface to be polished made flat by an emery wheel or file, and the sharp edges rounded to prevent cutting into the wax. The dimensions of the samples should depend to some extent upon the coarseness of structure. For normal iron and steels, and for much other work, a $\frac{3}{8}$-in. cube is a convenient sample. Massive castings sometimes have grains an inch or more in diameter, and correspondingly large samples are required. The samples are held flat against the waxed discs, which are kept well covered by the polishing-paste, using successively the flour of emery, the 3/0 emery, the 7/0 emery, and the rouge, on the several discs. At each grinding with emery the sample should be held without rotation and with a slow transverse motion across the face of the disc until the grinding marks show over the entire surface. The sample may then be given a quarter turn, so that the new marks cross the old ones, and so on. The discs must be kept wet continually while grinding. With each grade of powder the grinding should continue for some time after the marks of the last previous grade have disappeared, especially with soft metals, since the scratches cause a flow or disturbance of the metal to a minute depth below the surface, and if this disturbed metal is not ground off, the deep effect of the scratches becomes apparent on etching. In the final polishing on the rouge disc, the sample should be continuously rotated; this is most readily done by moving the sample nearly in a circle about the center of the disc in an opposite direction from the rotation of the disc. This keeps the direction of the grinding marks constantly changing, and avoids grooving. The finishing should be done near the center of the disc, the slower motion being most effective for very fine polishing. After grinding with one grade of powder and before proceeding to the next, the samples and the operator's hands should be thor-

oughly washed; and the hands and the apparatus should be kept free of dust or dirt, to secure a polish free from scratches.

11 The most important item to be noted by the beginner is the liability of the paraffin to adhere to the samples when the grinding is begun, particularly in the case of the rouge disc. When the sample is first brought into contact with the disc, especially if the latter has been freshly prepared, the paraffin nearly always smears over the surface of the sample in a second or two, and if the sample is not removed and cleaned at once the result is a roughened disc, requiring re-turning with the hand-tool and re-application of the paste. Therefore the sample should at first be touched very lightly to the disc, and at once removed and wiped with the finger, or with a cloth. If this is repeated several times, the surface of the sample will no longer become coated with paraffin but can be ground continuously, except when a fresh coating of paste is required by the disc. One great advantage of the paraffin disc over discs covered with cloth or felt, is that if the disc becomes roughened or cut, it can readily be turned smooth and true again.

12 For cleaning the samples after polishing, the best material is a stock of old linen or cotton cloth well-laundered and cut to 3-in. squares. These small pieces are preferable to larger ones, since they can be discarded for fresh ones after once using. The old cotton or linen is also the best material for cleaning the lenses and mirrors of the optical apparatus, being superior to chamois for this purpose.

13 The time required for polishing a sample varies somewhat with the hardness. A single sample of normal steel, cast-iron, or wrought-iron, may be finished in fifteen minutes; a set of five or six such samples may be finished in an hour. Hardened steels require a slightly longer time. The method has not thus far proved serviceable for very soft metals and alloys, particularly lead, owing to the persistent adhesion of the paraffin to the surface of the sample. The harder alloys polish well by this process. The finished surface presents a minute relief of the harder constituents, but much less than is produced by the use of felt or other very soft materials.

14 The paraffin beds are more durable than might be supposed; on long standing at summer temperatures the surfaces become distorted by the flow of the wax, but they can always readily be made true by the turning tool. The harder paraffin (ceresin) offers no advantages over ordinary paraffin, except that it flows less at summer temperatures. It is serviceable for use with the emery powders but too hard for best results with the rouge.

A NEW TRANSMISSION DYNAMOMETER

By Prof. Wm. H. Kenerson, Providence, R. I.
Member of the Society

The author has received from time to time many requests for a simple transmission dynamometer, and has himself often felt the need of one which would be more generally applicable than those now in use. These continued requests, together with the requirements of a definite problem whose solution demanded a rigid transmission dynamometer in the form of a coupling, led to the design and construction of the instrument described below. The accompanying illustrations show the construction of the dynamometer and its method of application and use. In Fig. 2 and Fig. 4 the corresponding parts of the dynamometer are given the same letters and are referred to in the text.

2 The couplings *A* and *B*, each keyed to its respective shaft, are held together loosely by the stud bolts *C*. The holes in the flange *A* are larger than the studs *C*, so that these studs have no part in transmitting power from one shaft to the other. The power is transmitted from *A* to *B* through the agency of the latches *L*, four of which are arranged around the circumference of the flange *B*. These latches are mounted and are free to turn on the studs *E*. The two fingers of the latches engage the studs *F* on the flange *A*. On the ends of each latch are knife-edges parallel to the stud about which the latch turns. For either direction of rotation of the flange *A* the latches *L*, which are in effect double bell-crank levers, will exert a pressure on the disc *G*, tending to force it axially along the hub of the coupling *B*, and this pressure, it will be seen, is proportional to the torque.

3 Between the end-thrust ball, or roller, bearings *M M*, is held the stationary ring *S*, which is the weighing member. *O* is a thrust-collar screwed on the hub of *B*, and *P* is its check nut, which is ordinarily pinned to the hub when in position. The stationary member

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S, in the form of a ring surrounding the shaft, is prevented from rotating by fastening to some fixed object the attached arm shown in the view (Fig. 1) of the assembled instrument. In this ring is an annular cavity covered by a thin, flexible copper diaphragm *D*, against which the ball-race of one of the thrust-bearings presses. The edge of this ball-race is slightly chamfered to allow some motion to the diaphragm. The cavity is filled with a fluid, such as oil, and connected by means of a tube to a gage. The oil pressure measured by the gage is proportional to the pressure between the thrust-bearings, which in turn is proportional to the torque.

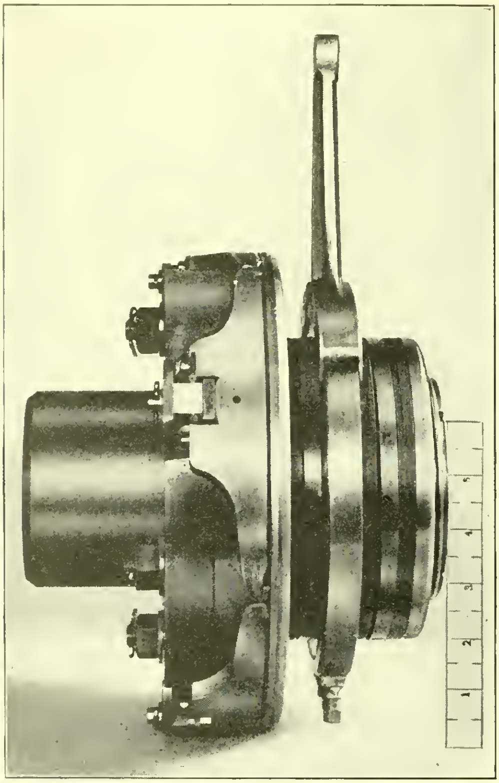

Fig. 1 Dynamometer for 2-in. Shaft, Weight 60 lb.

4 The instrument may be calibrated in the torsion-testing machine or by means of a sensitive friction brake. Fig. 6 is an actual calibration curve for a small instrument, obtained by hanging standard

weights at proper distances from the shaft on a horizontal lever attached to the shaft, and reading the pressures indicated by the gage for the various torques shown in the diagram. For ordinary purposes, however, it is not necessary to calibrate the instrument by actual trial, since computations of the oil pressures for the various torques from the lengths of the lever-arms and diaphragm area check very closely those thus obtained.

5 It will be seen that the weighing means is similar to that employed in the Emery testing-machine, which is recognized as being extremely accurate. It will be possible to employ the Emery flexible steel knife-edges on the levers, if desired, but this has been found in practice an unnecessary refinement.

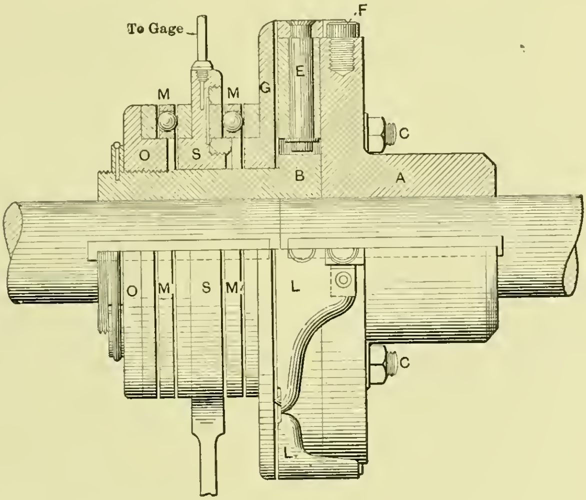

FIG. 2 DYNAMOMETER SHOWN IN SECTION

6 The construction makes the coupling as nearly rigid as materials will permit, the movement of the diaphragm being extremely small. The only flow of oil through the copper connecting-pipe is that sufficient to alter the shape of the Bourdon tube, if that be the form of gage employed. As soon as the normal position of the gage is reached this flow ceases, hence there can be no fluid friction. It is possible therefore, to use as long and as small a tube as desired, without introducing error. Where the gage is placed at a distance above or below the coupling, correction should of course be made for the static head.

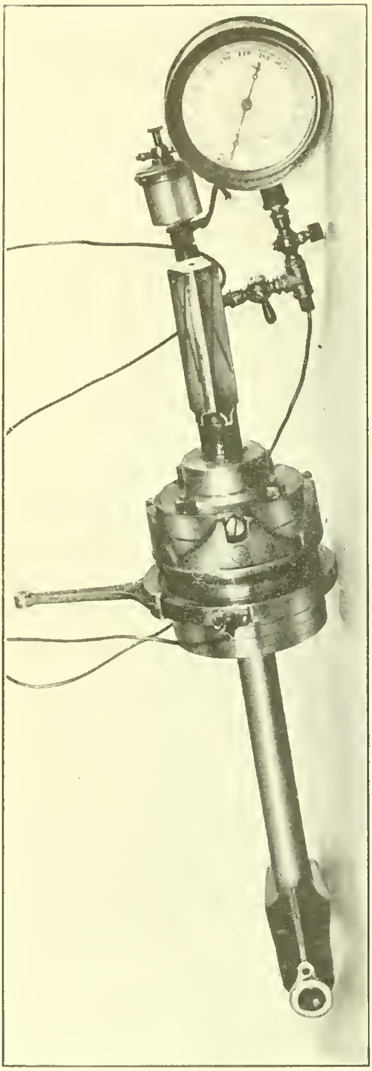

Fig. 3 Transmission Dynamometer in Automobile Propeller Shaft, 30 h.p. at 500 r.p.m., Weight 25 lb.

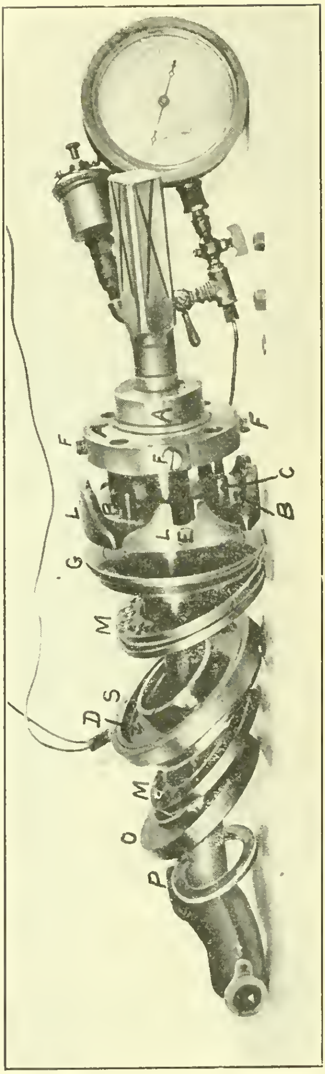

Fig. 4 Transmission Dynamometer Taken Apart to Show Construction

7 Other means than the gage shown may be employed to measure the fluid pressure. Where extreme accuracy is desired it will be well to employ the weighing-device used with the Emery testing-machine. The manograph has been used in this connection to measure variations in torque too rapid for indication by the ordinary gage. For example, the variations in torque in a single revolution of the shaft of a 3-cylinder gasolene engine have been recorded with its aid.

8 Where the rate of rotation of the shaft is variable and it is desired to indicate the horsepower direct, the combination of gage and tachometer shown in Fig. 7 is employed. The hydraulic gage is connected to the coupling described, its pointer therefore indicating torque. The pointer of the tachometer shows the number of revolutions per minute. Being a function of the revolutions per minute and the torque, the horsepower will be indicated by the intersection of the two pointers and suitable curves on the dial as shown. Arrangements for recording or integrating the work done may also be attached to the coupling.

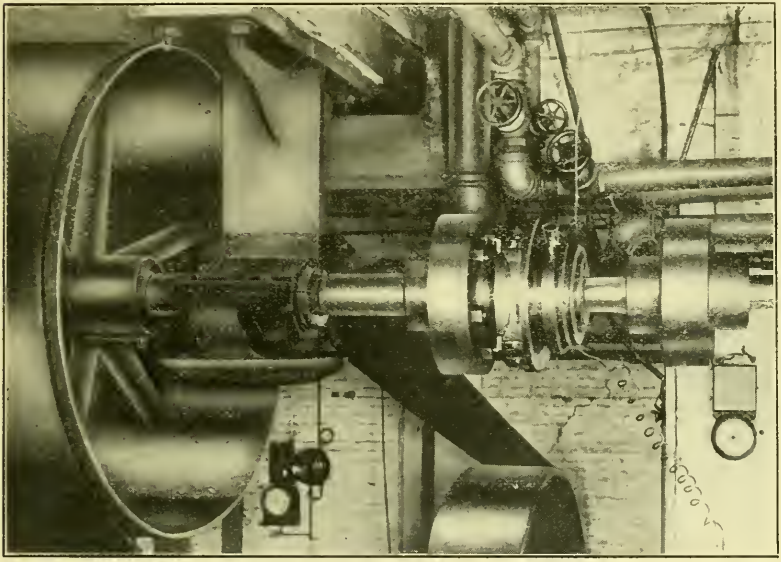

Fig. 5 Dynamometer Placed between Flanges in Machine-Shop Drive shaft 3 in. in diameter. Spiral running to the wall is oil-pipe to gage

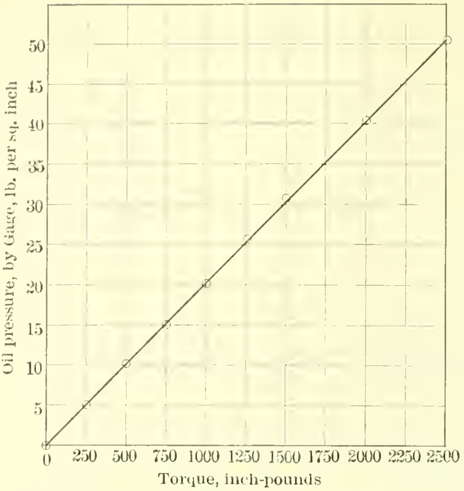

Fig. 6 Calibration Curve for Transmission Dynamometer

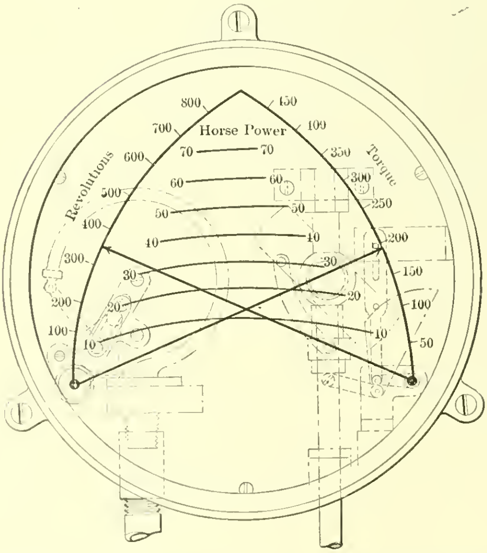

Fig. 7 Combination Pressure-Gage and Tachometer Indicating Torque, Revolutions per Minute and Horse Power

9 A summary of some of the more important characteristics of the instrument follows:

a The instrument is compact. The example shown in Fig. 3 and Fig. 4, which is designed to transmit 30 h.p. at 500 r.p.m., is about $5\frac{3}{8}$ in. in diameter and weighs about 25 lb. That shown in Fig. 5 driving a 3-in. shaft is about 13 in. in diameter and weighs about 160 lb.

b It is as rigid as an ordinary flange coupling.

c It may be made in the form of a coupling, and will then occupy about the same space as the usual flange coupling, or it may be made in the form of a quill on which a pulley is mounted. This form may be made in halves for application to a continuous shaft.

d It will indicate for either direction of rotation of the shaft.

e The torque may be read and recorded or the work integrated at a considerable distance from the coupling.

f The readings do not require correction for different speeds of rotation. All parts containing oil are stationary, hence are unaffected by variation in speed. Other parts are likewise unaffected by centrifugal action.

g It may be made very sensitive and accurate. The construction lends itself very easily to variation of range of application and to varying degrees of sensitiveness, since the oil pressure, and hence the sensitiveness of the instrument, depend upon the area of the diaphragm, the relative lengths of the arms of the latches *L*, and the diameter of flanges. Its accuracy is dependent mainly on the degree of accuracy of the means employed to measure the fluid pressure, of which a number of forms, other than the usual pressure-gage, are available.

h The only power absorbed is the small amount due to the friction of the ball, or roller, bearings, and this can be determined from the pull of the retaining arm. It is unnecessary to make correction for this, however, since the amount is so small as to be negligible.

i Since the only wearing parts are the ball, or roller, bearings, which may be lightly loaded, the instrument should not be deranged easily. Because of the very small volume of oil contained in the weighing chamber, ordinary temperature changes do not affect the calibration. All parts containing oil are stationary, hence all joints may be soldered and leakage entirely prevented.

j With suitable material and ordinary workmanship, it is believed that there is little likelihood of failure of any part of the instrument. It is conceivable, however, that the balls or rollers, although lightly loaded, might crush; the diaphragm might shear; or the stationary member, although bearing only its own weight and lubricated, might seize to the hub. Remote as are any of these possibilities, should any or all of them occur, the worst that could happen would be the tearing-off of the oil pipe and retaining arm, when the whole would revolve as a solid coupling. In no case can the coupling fail to drive the shaft because of its variation from the standard form, since, in addition to the driving-latches employed to carry the load normally, the same number of connecting bolts may be employed as in the ordinary coupling, which will still hold the coupling together should the latches fail. Since, however, these latches are farther from the shaft, they should, if properly constructed, be less likely to fail than the connecting bolts usually employed.

10 It is believed that uses for the instrument here described will suggest themselves, and it is with the hope that the device will prove of some interest to those who deal with the use and transmission of power that the matter is presented to the Society.

SMALL STEAM TURBINES

By George A. Orrok, New York

Member of the Society

The papers upon steam turbines which have been presented before the Society have dealt mainly with the larger types of apparatus and have been written to show the reliability, efficiency and general desirability of this type of prime mover.

2 This paper treats of the smaller sizes of steam turbines from the standpoint of the designing and operating engineer, describing the commercial machines in sufficient detail, with reference to the service to which they have been applied, and giving certain facts concerning their operation which may be of advantage to the engineering profession. Curves of steam consumption are given which show in a general way what may be expected of these machines under certain conditions.

3 At the present time seven machines are on the market and can be obtained in various sizes from 10 h.p. to 300 h.p. with reasonable deliveries. These are the De Laval, Terry, Sturtevant, Bliss, Dake, Curtis and Kerr turbines. Three other machines are nearly at this stage of development and patents have been applied for on several others.

4 Many thousand horsepower of these turbines have been sold and are in successful commercial service. The following reports of total sales of sizes from 10 h.p. to 300 h.p. have been obtained from the manufacturers:

To be presented at the Washington Meeting (May 1909) of The American Society of Mechanical Engineers. All papers are subject to revision.

For further discussion of Steam Turbines, consult Transactions as follows: Vol. 10, p. 680, Notes on Steam Turbines, J. B. Webb; vol. 17, p. 81, Steam Turbines, W. F. M. Goss; vol. 22, p. 170, Steam Turbines, R. H. Thurston; vol. 24, p. 999, Steam Turbines from the Operating Standpoint, F. A. Waldron; vol. 25, p. 1056, The De Laval Steam Turbine, E. S. Lea and E. Meden; vol. 25, p. 1041, The Steam Turbine in Modern Engineering, W. L. R. Emmet; vol. 25, p. 782, Different Applications of Steam Turbines, A. Rateau; vol. 25., p. 716, Some Theoretical and Practical Considerations in Steam Turbine Work, Francis Hodgkinson.

De Laval,	De Laval Steam Turbine Company................	70,000 h.p.
Curtis,	General Electric Company......................	70,000 h.p.
Terry,	Terry Steam Turbine Company..................	15,000 h.p.
Kerr,	Kerr Turbine Company.........................	10,000 h.p.
Sturtevant,	B. F. Sturtevant Company.....................	
Bliss,	E. W. Bliss Company..........................	
Dake,	Dake-American Steam Turbine Co...............	

5 All of these machines are of the impulse type: that is to say, the steam is expanded in a nozzle and the kinetic energy of the jet is absorbed by passing one or more times through the buckets of the turbine rotor. In the De Laval turbine only one moving element and one steam pass are used, which necessitates a very high bucket velocity. In the Terry, Sturtevant, Bliss and Dake turbines a series of return passages is provided. The steam returns two or more times to the same rotor and the bucket speed is much lower. In the Kerr turbine the steam is used in stages with one bucket wheel in a stage; while in most of the Curtis machines two or three stages are used with two or three rows of moving buckets, separated by stationary guide blades, in each stage. Compound machines of the other types have been made but are not as yet produced commercially.

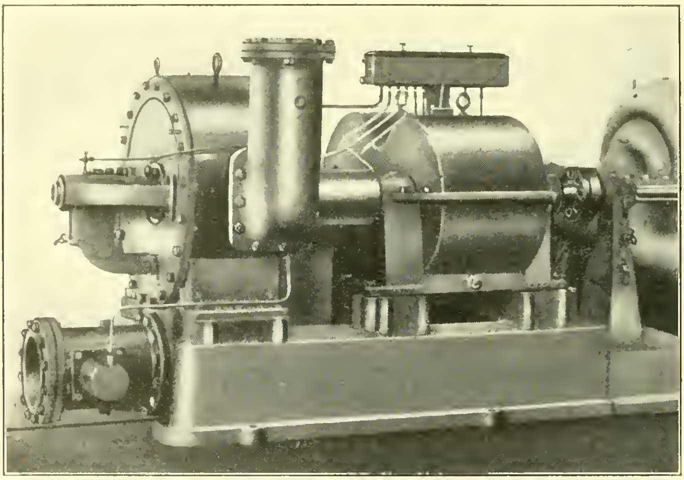

Fig. 1 High and Low-pressure De Laval Turbine

6 By far the larger number of these machines is used in connection with extra high-speed electric generators, the next larger application

being to centrifugal fans for high pressures. Centrifugal pumps adapted to high rotative speeds have been rather generally introduced in the last few years and it is becoming usual to connect small turbines direct to these machines. The small space required and the simplicity obtainable in a 100-h.p. turbine at speeds of from 800 to 1200 r.p.m. has been an important factor in their introduction.

7 The first of the small turbines to be put on the market was the De Laval, made by the De Laval Steam Turbine Company of Trenton, N. J., and introduced in this country about 1896. This machine is of the pure impulse type; the steam being expanded in the nozzle down to the exhaust pressure, and the resultant velocity transferred to the wheel in one steam pass. The bucket speed is high, ranging from 600 to 1300 ft. per sec. Eight sizes of wheels are made, generating from 10 h.p. to 500 h.p., with one nozzle in the smallest size and eight or more in the 500-h.p. size.

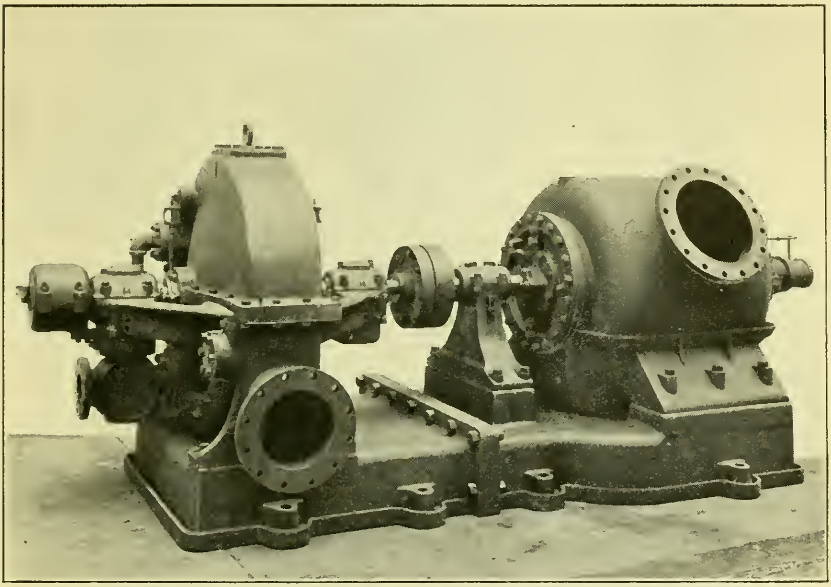

Fig. 2 Terry Steam Turbine, 36-in.

8 The high bucket speed necessitates the use of gears of special construction, which have been very successful. The design, construction, and economy of this type have been discussed in Vol. 25 of Transactions, p. 1056.

9 The Terry Turbine, made by the Terry Steam Turbine Company of Hartford, Conn., has been manufactured for about ten years, although the commercial machine has been on the market only for about four years. This turbine is of the impulse type, but the steam passes through the buckets a number of times before its energy is absorbed. The case of the machine is parted on a horizontal plane through the shaft and at right angles to the wheel. The nozzles and return passes are bolted to the inside of both parts of the casing. The nozzles are in the plane of the side of the wheel. The return passages are of brass and are separated by partitions. The wheel itself is built up of two steel discs held together by bolts over a steel center. The buckets are built of steel punchings, fitting in grooves cut in the discs, as shown by the figures. The sizes of wheels manu-

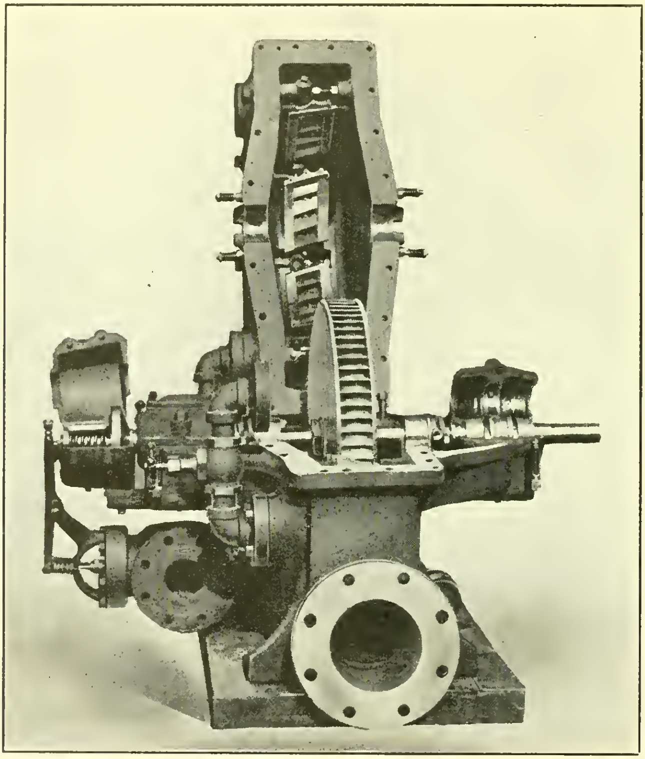

Fig. 3 Terry Turbine Showing Construction

factured at the present time are 12, 18, 24, 36 and 48 in., and the number of nozzles varies from two on the 12-in. wheel to eight or ten no the 48-in. wheel.

10 The Sturtevant Turbine, made by the B. F. Sturtevant Company of Hyde Park, Mass., has been in the development stage for three or four years and quite a number of machines have been sold. The present type of turbine may be called "standard," however, and four sizes of wheel are built, 20, 25, 30 and 36-in., developing from 3 h.p. to 300 h.p. The turbine is of the multiple-pass type similar to the Riedler-Stumpf. The casing is cast solid with one end. The nozzle and return chamber ring are inserted from one side and the wheel is milled from the solid. The return passages are from eight to twelve in number and are milled on the inside of the return chamber ring. They are partitioned and are similar in shape to the buckets. The nozzle lies in the plane of the side of the wheel.

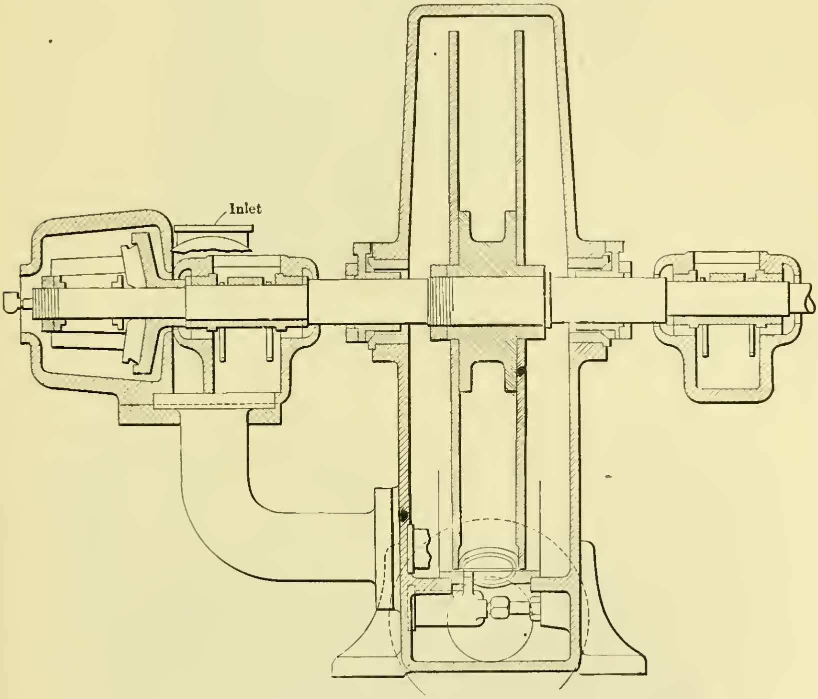

Fig. 4 Sectional View of Terry Turbine

11 The Bliss turbine, formerly known as the American, made by the E. W. Bliss Company of Brooklyn, N. Y., is of the same type as

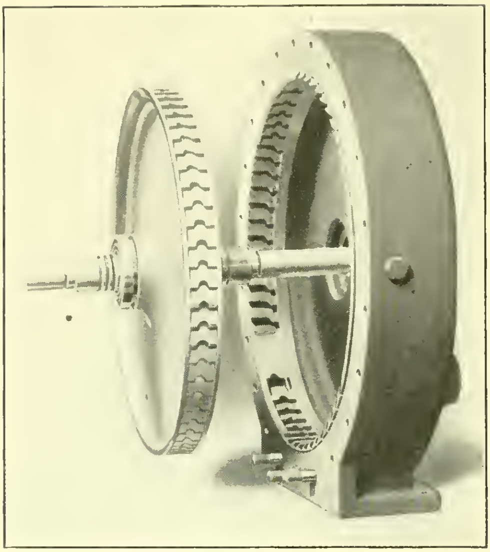

Fig. 5 Wheel and Casing of Sturtevant Turbine

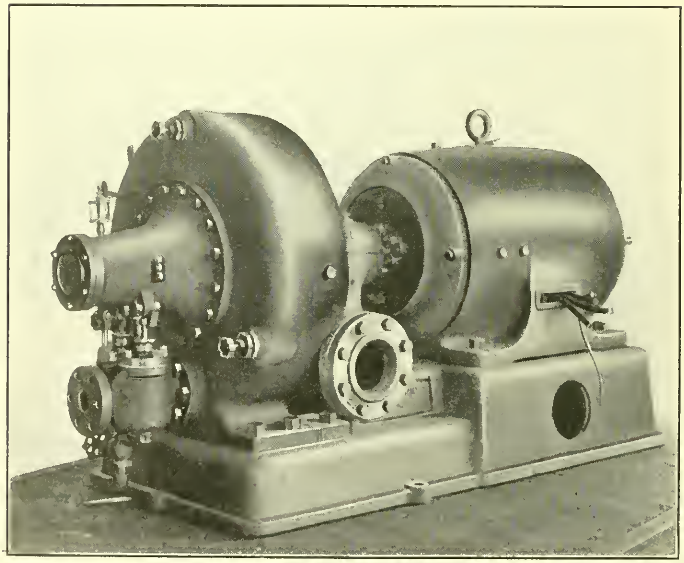

Fig. 6 Sturtevant Steam Turbine, 30-in.

the Terry and Sturtevant and has been on the market only a few months. The casing and steam chamber are cast solid with one side and the nozzle and return chambers bolted in. The wheel is milled from a steel casting, or forging in the smaller sizes, and the partitions separating the buckets are inserted and held in place by three bands of steel shrunk on the face of the wheel. The return passages are peculiar in having no partitions. Two sizes of wheel have been built, the 42-in. and 30-in., but designs have been developed for the 12, 18, 24, 36, 48 and 60-in., covering powers from 10 h.p. to above 600 h.p.

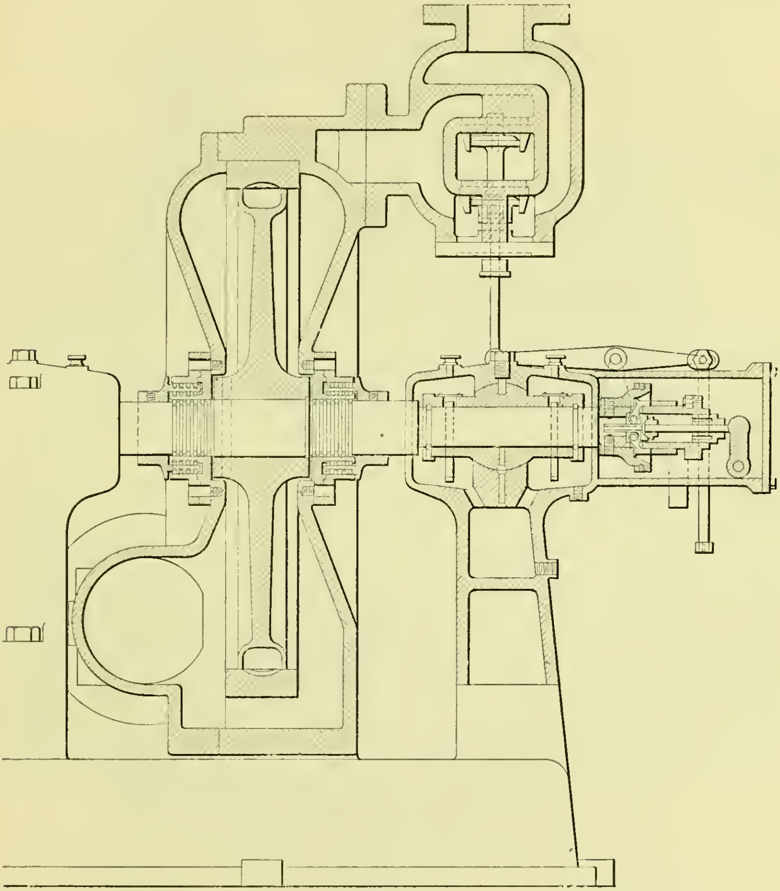

Fig. 7 Section of Sturtevant Turbine

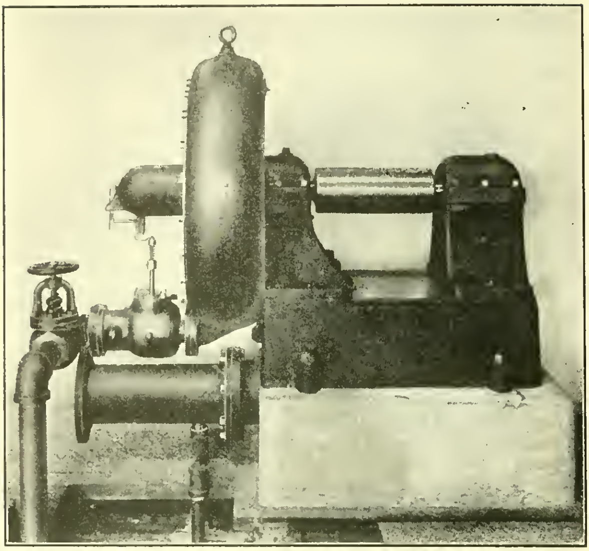

Fig. 8 Bliss Turbine, 30-in.

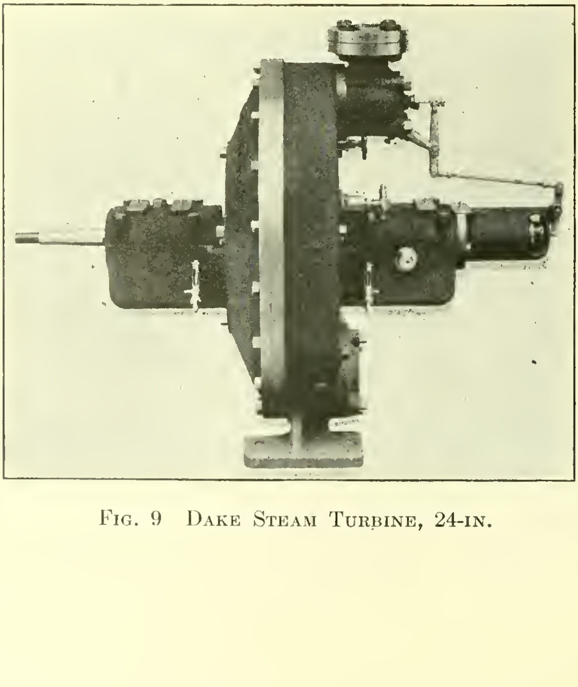

Fig. 9 Dake Steam Turbine, 24-in.

12 The Dake turbine, made by the Dake-American Steam Turbine Company of Grand Rapids, Mich., is a single-stage impulse turbine. The wheel is made of two bucket discs, with milled buckets and inserted partitions, bolted together over a wheel center. In their Headlight turbine the governor is enclosed between the sides of the wheel. The nozzles and return-passages are placed between the bucket discs. The machine is built in sizes of from 5 h.p. to 100 h.p., the diameter of the smallest wheel being 12 in.

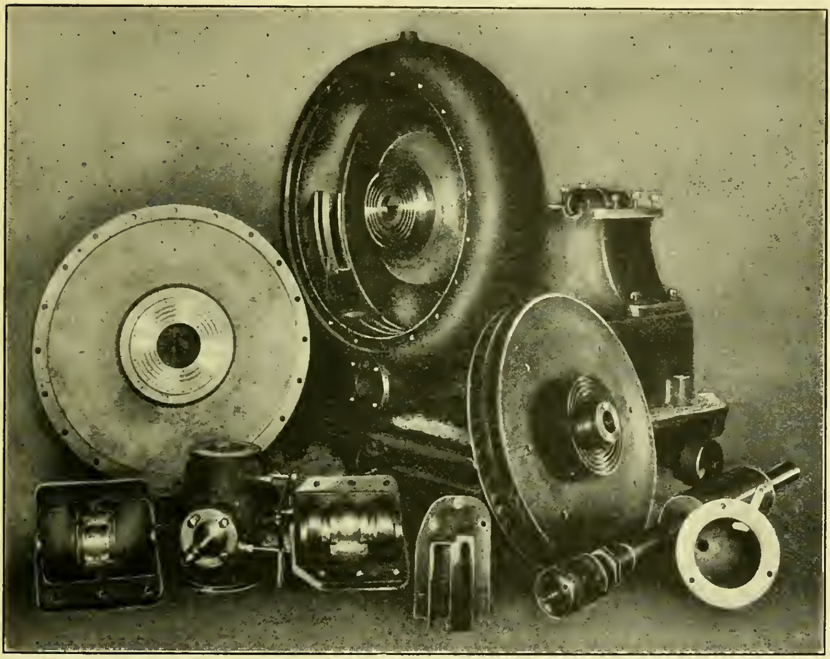

Fig. 10 Bliss Turbine Dissembled

13 Coincident with the development of the large Curtis turbines, the General Electric Company, at their Lynn Works, have developed and placed on the market a line of small generating sets ranging from 5 kw. to 300 kw. This range is covered by eight sizes, the smaller machines being single-stage with two or three passes per stage. The buckets and nozzles are of the well-known Curtis type.

14 The Kerr Turbine, made by the Kerr Turbine Company of Wellsville, N. Y., is of the compound impulse type. It is generally built in from two to eight stages. The buckets are of the double

Pelton type, inserted like saw teeth in the wheel disc. Four sizes of wheels, 12, 18, 24 and 36 in., are made and cover a range of from 10 h.p. to 300 h.p. The nozzles are in the plane of revolution of the wheel and are screwed into the stage partitions and held in place by a lock nut.

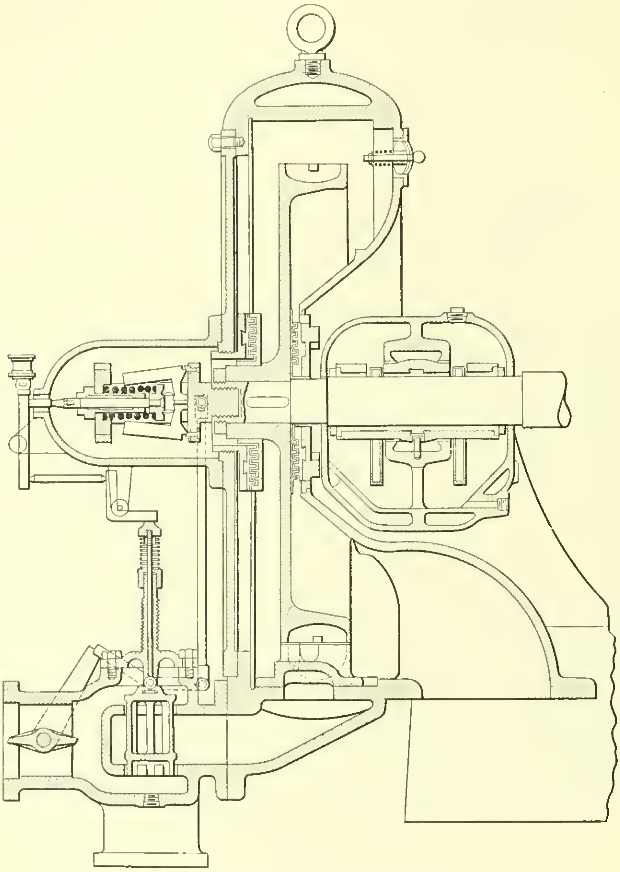

Fig. 11 Sectional View of Bliss Turbine

15 As in large turbines, details of these small turbines, to which reference has been made, show the skill and knowledge of the designer, and that the same problem may be solved in different ways is well illustrated by the sections here reproduced.

DESCRIPTION OF DETAILS

16 *Nozzles.* The diverging nozzle is used by all makers except Kerr, whose multi-stage wheel requires a converging nozzle. In the De Laval, Sturtevant and Kerr turbines, the nozzles are screwed into their seats; that of the Terry is held in place by a bolt. The nozzles of the Curtis, Dake and Bliss turbines are reamed out of the solid. The larger sizes of the De Laval machine which have been put on the market lately have a large number of reamed nozzles instead of the older construction.

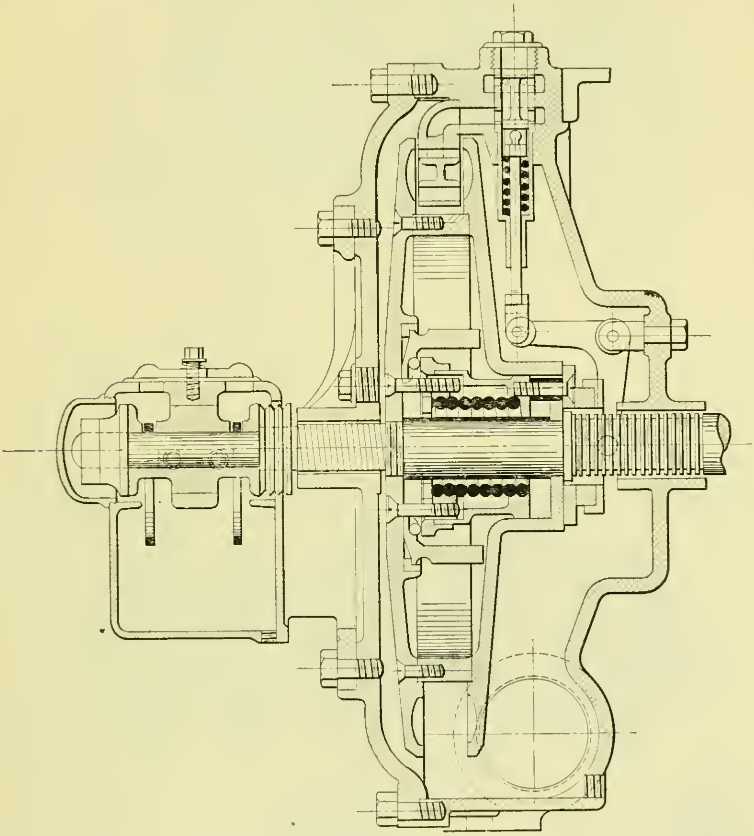

FIG. 12 SECTION OF DAKE HEADLIGHT TURBINE; EXTERIOR SHOWN IN FIG. 9

17 *Buckets.* The constructions employed in the Curtis and De Laval wheels are well-known and have been described many times.

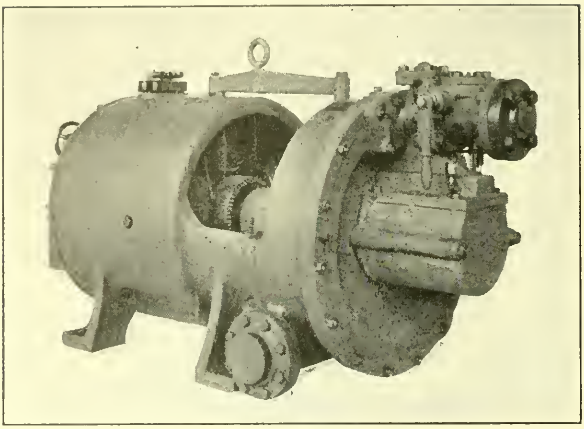

Fig. 13 Curtis Turbine, 50 h.p.

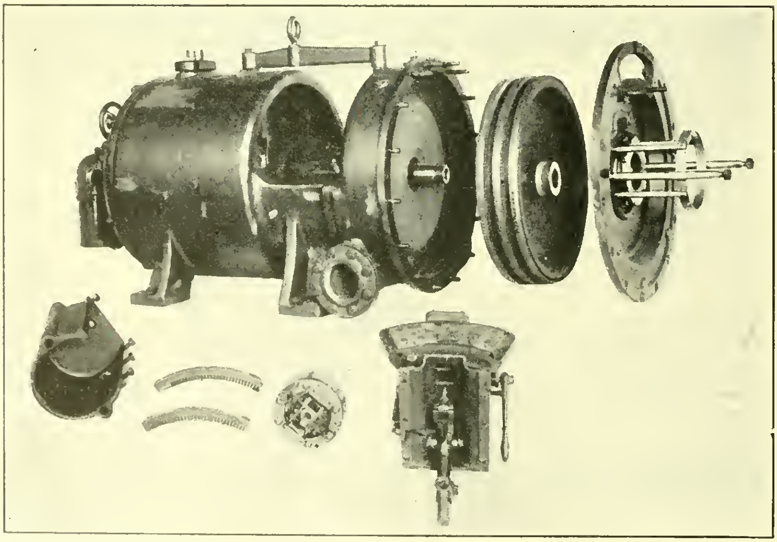

Fig. 14 Curtis Turbine in Process of Assembly

The Terry, Dake, Bliss and Sturtevant buckets are practically semicircular in form. The Terry bucket is constructed entirely of steel punchings assembled between grooves in the two steel discs forming the sides of the wheel. The Sturtevant wheel is milled out of a steel casting. The Bliss buckets are milled out, but the partitions are inserted and held in place and steel rings are shrunk on. The Dake buckets are turned out of the solid, the recesses for the partitions milled out and the partitions inserted; the wheel is then bolted together. The Kerr buckets are very similar to the original Pelton buckets and are inserted in the wheel in a manner similar to the De Laval buckets.

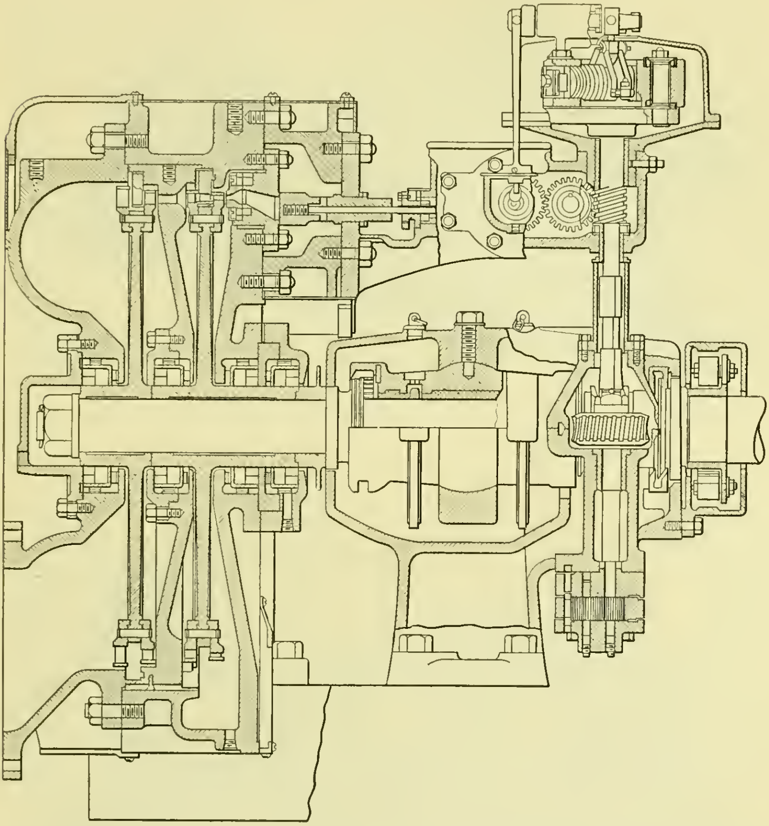

FIG. 15 SECTION OF CURTIS TWO-STAGE, NON-CONDENSING TURBINE, 160 H.P.

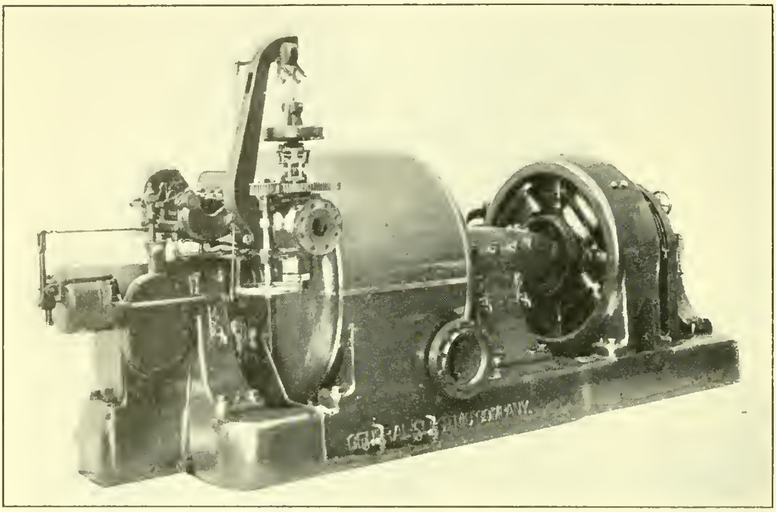

Fig. 16 Curtis Turbine, 200 h.p.

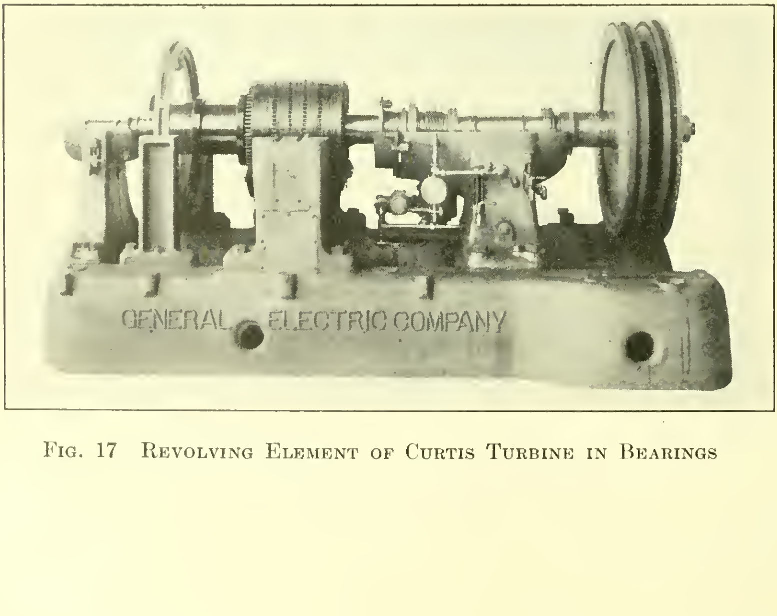

Fig. 17 Revolving Element of Curtis Turbine in Bearings

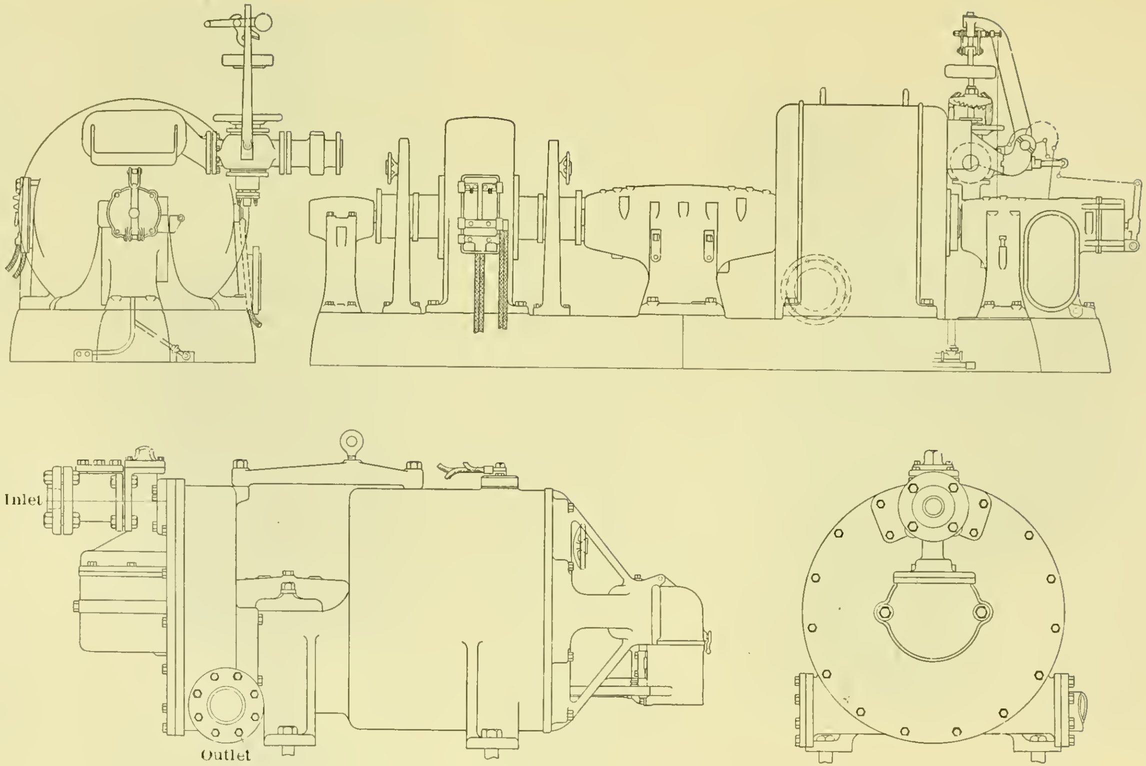

FIG. 18 DIAGRAMS OF CURTIS TURBINES, 200 H.P. AND 50 H.P.

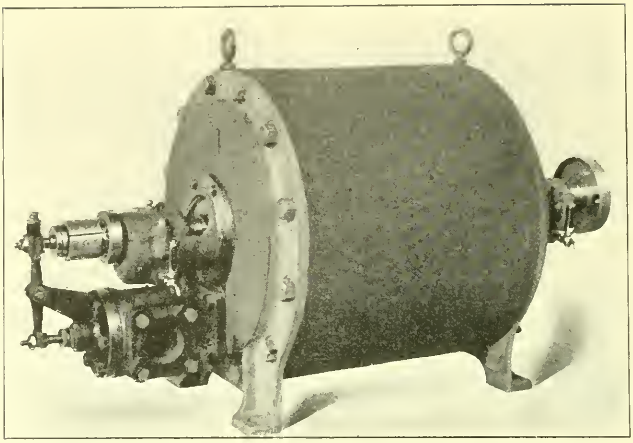

Fig. 19 Kerr Turbine, 18-in.

18 *Return Chambers.* The Sturtevant returns are milled out of the solid ring. Bliss casts them in the nozzle piece and finishes them by hand; Terry casts each one separately, finishes by hand and assembles with bolts; Dake casts the return chambers solid, mills the passages and covers them with a shrouding.

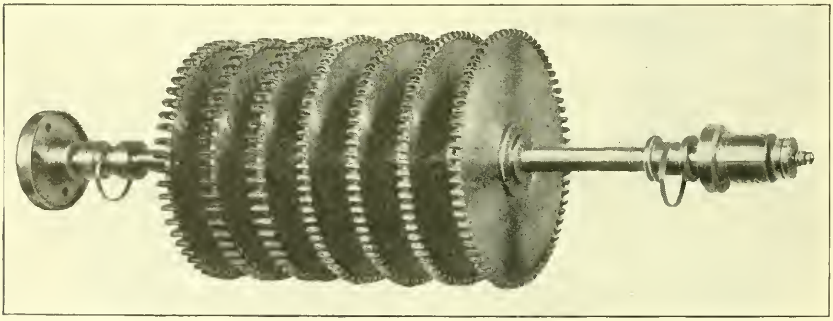

Fig. 20 Complete Rotating Part, 18-in., 7-Stage, Kerr Steam Turbine

19 *Wheel Centers.* De Laval, Curtis, Sturtevant and Bliss make the wheel centers of steel castings or forgings integral with the wheel. Terry uses a steel casting but bolts the wheel disc to it. Kerr uses a screwed coupling, the inner part cut in three pieces and keyed to

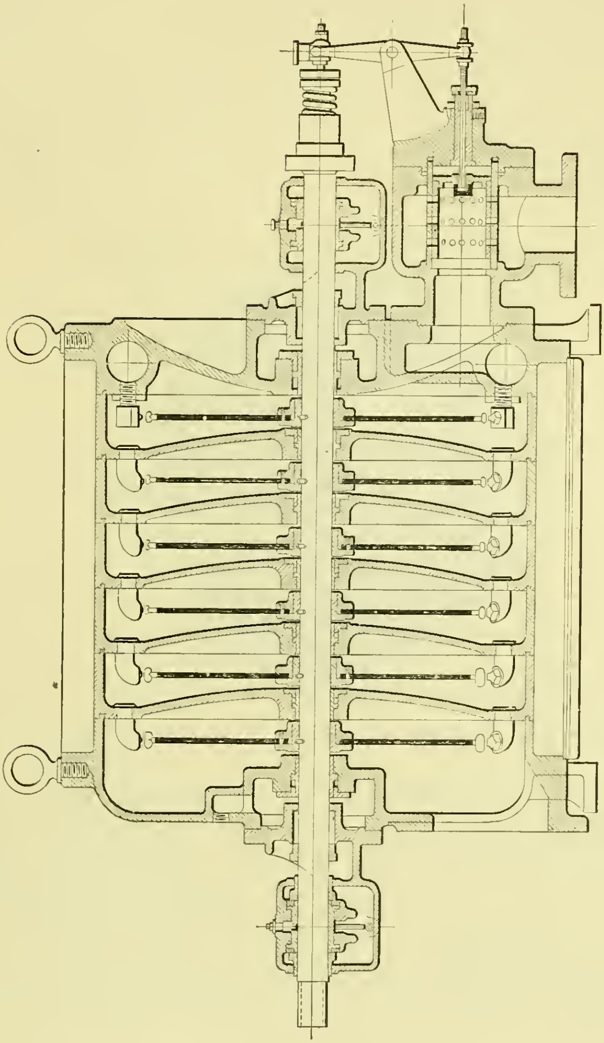

Fig. 21 Kerr Turbine, Sectional View

the shaft with round keys, clamping the wheel disc. Dake's wheel centers are an integral part of the wheel in small sizes, but in the larger machines are steel castings, in some cases a part of the shaft.

20 *Governors.* De Laval, Terry, Sturtevant, Bliss, Dake and Kerr use a flyball governor on the shaft end, which actuates the throttle valve through a system of levers. Curtis uses the flyball governor on the shaft for small sizes and slower-speed spring-controlled governors of different forms for the larger sizes. The Sturtevant, Bliss and Curtis machines are provided with an emergency stop governor as well as the throttling governor.

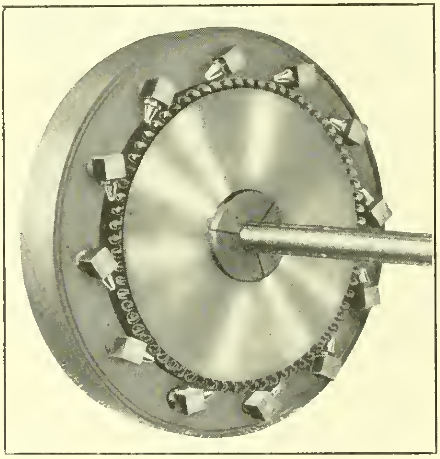

Fig. 22 One Stage of Kerr Turbine, Showing Nozzles and Wheel

21 *Glands.* For non-condensing machines glands are not troublesome, as the difference of pressure between the casing and atmosphere is rarely more than a few pounds. Terry uses a bronze ball-and-socket gland with a long loose fit on the shaft. Sturtevant and Dake use a set of ring packing, either cast-iron or bronze. Bliss has a labyrinth packing without contact. Kerr has a floating bronze bush with soft packing behind it. Curtis uses a metallic packing held in place by a gland-ring, and for condensing service a carbon-ring packing, steam-sealed.

22 *Clearance.* In none of these machines is clearance an important factor. The clearance between buckets and guide-passages on a 24-in. wheel is usually from $\frac{1}{16}$ in. to $\frac{3}{32}$ in. when hot. Striking or rubbing is practically unknown.

23 *Thrust.* Theoretically, there should be no thrust in any turbine of these types. Practically, there is always a very small thrust one way or the other. This thrust is usually taken care of by small thrust-collars or washers next to the bearings. Thrust from

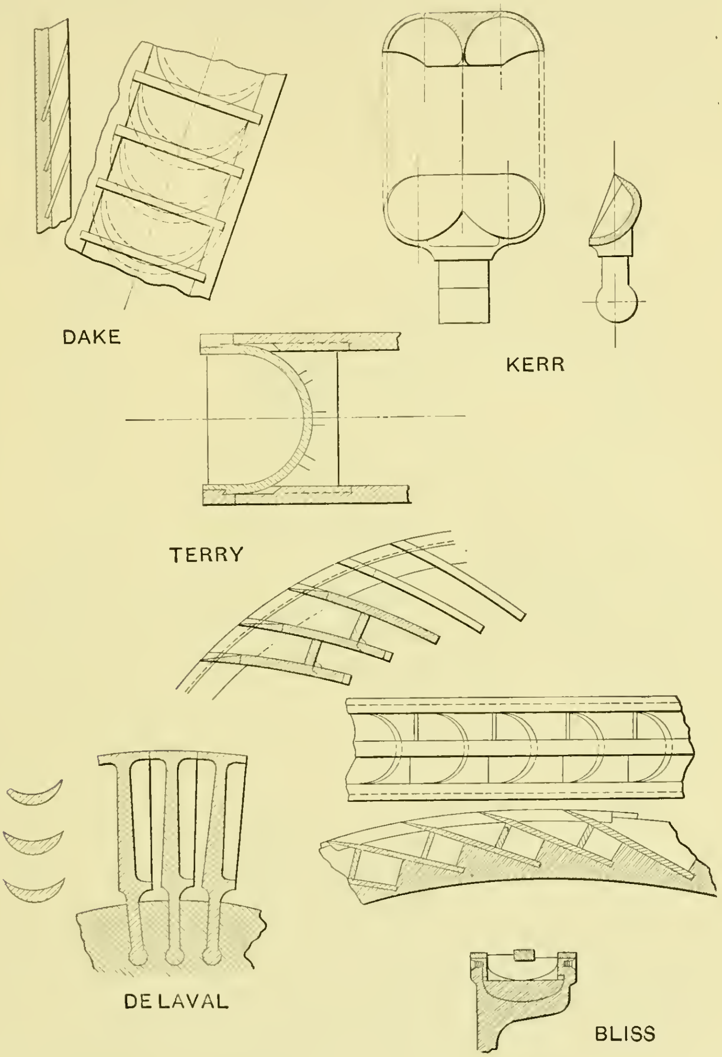

Fig. 23 Typical Turbine Buckets

the outside is prevented by the use of a flexible coupling between the turbine and the machine it drives.

24 *Bearings.* The bearings are always ring-oiled with large oil reservoirs, sometimes, on the larger sizes, provided with water jackets or water cooling pipes for an emergency cold-water circulation. The lubrication of the thrust is obtained at the same time.

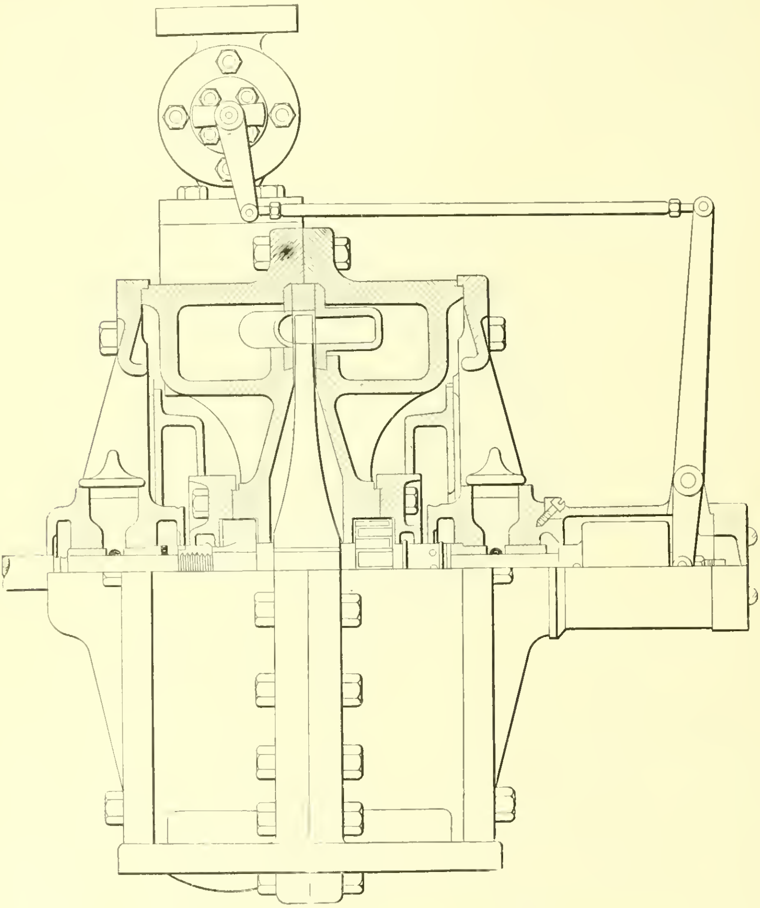

FIG. 24 SECTION OF WILKINSON STEAM TURBINE, 20-IN.

25 *Operation.* These machines are nearly automatic in their operation. When the machine is once properly set, the coupling properly adjusted and the bearings supplied with oil, the machine may

run for years without an overhauling. The bearings must be looked after to see that no heating takes place and that the ring is carrying the oil to the shaft. The coupling should be examined from time to time to make sure that no thrust is communicated through it to the turbine. With these precautions a three months' continuous run is common and a number of turbines have to my knowledge run more than eighteen months without a cent spent on them for maintenance. Apparently there is no wear in nozzles, buckets, or return chambers.

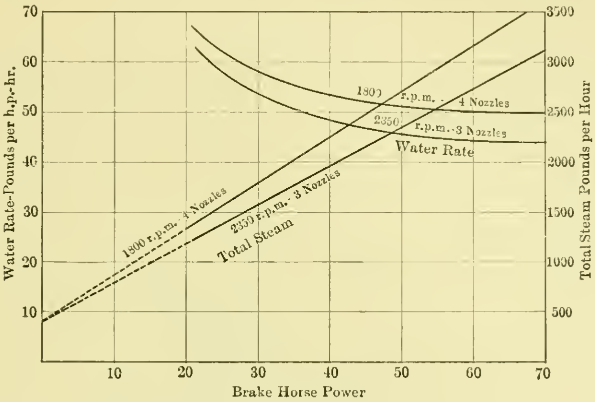

FIG. 25 STEAM CONSUMPTION CURVES, TERRY TURBINE

24-IN. WHEEL, 150-LB. PRESSURE, NO SUPERHEAT, NON-CONDENSING. TESTED BY WESTINGHOUSE MACHINE CO., PITTSBURG, PA.

The only wearing parts are the bearings and these are generously proportioned.

26 These machines may be taken apart and reassembled in half a day; some of them in two hours. The over-hung machines may be overhauled in an even shorter time.

27 *New Turbines.* The Hachenberg turbine, made by Wm. Gardam & Son, New York, is a compound impulse turbine resembling in construction the Dow turbine so frequently illustrated twenty years ago. Some experimental machines have been built, one of which was tested at Columbia University, and the commercial machine will soon be on the market.

28 James Wilkinson, of Providence, R. I., has a small steam turbine nearly in the commercial stage. A number of these machines are running, and within the next few months it is expected they will be on the market.

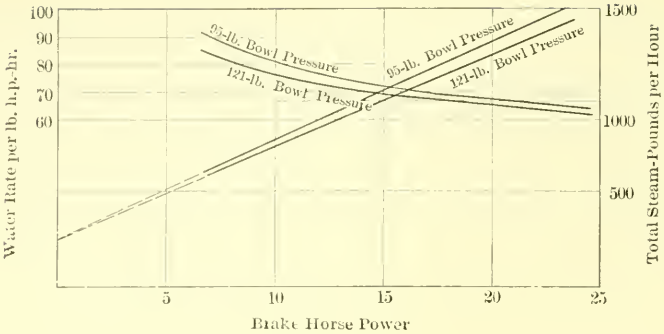

FIG. 26 STEAM CONSUMPTION CURVES, STURTEVANT TURBINE

20-IN. WHEEL, SINGLE-STAGE, NON-CONDENSING, 2400 R.P.M.

29 The Church turbine, lately completed by the Watson-Stillman Company and tested at Stevens Institute, is another promising turbine.

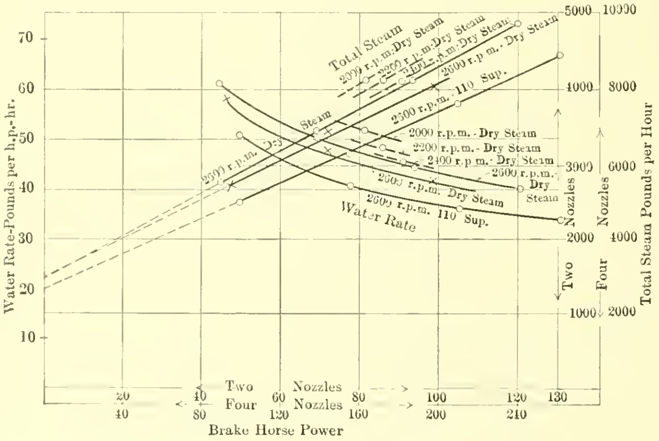

FIG. 27 STEAM CONSUMPTION CURVES, BLISS TURBINE, NON-CONDENSING

TESTED BY F. L. PRYOR AT HOBOKEN, N. J.
O = Two-nozzle, X = Four-nozzle

STEAM ECONOMY

30 The curves of steam economy have in most cases been obtained from the manufacturers. For the Curtis turbine speed-economy

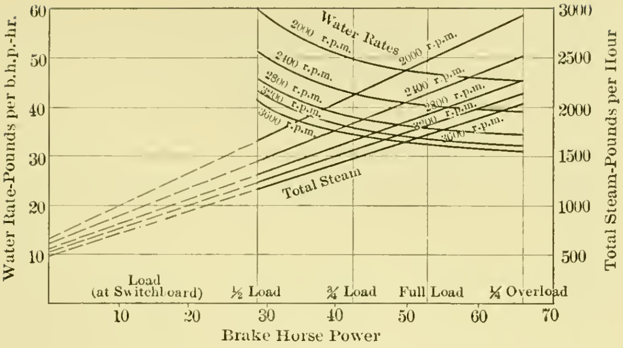

Fig. 28 Steam Consumption Curves, 200-h.p. Curtis Turbine

THREE-STAGE, 36-IN. WHEEL, CORRECTED TO 165-LB. ABS. BOWL PRESSURE, NO SUPERHEAT, NON-CONDENSING

curves are given for the 50 h.p. and 200 h.p. sizes. These curves represent the average of a large number of tests and have been corrected to bring them to standard conditions. The averages were consistent, and the variation from the average in any case was not large.

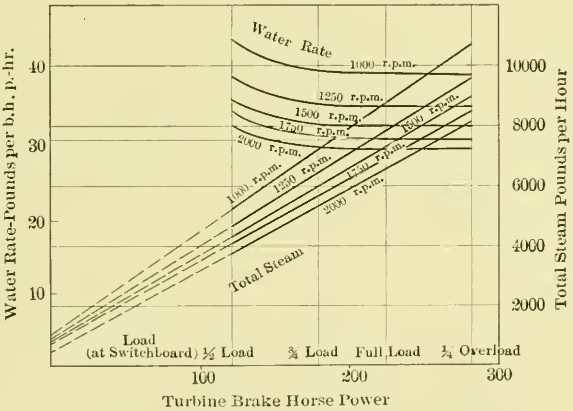

Fig. 29 Steam Consumption Curves, 50 h.p. Curtis Turbine

ONE-PRESSURE-STAGE, THREE ROWS OF BUCKETS, 25½-IN. WHEEL, CURVES CORRECTED TO 150-LB. BOWL PRESSURE, NO SUPERHEAT, ATMOSPHERIC EXHAUST

31 The curves for the Terry turbine were plotted from fourteen tests made at East Pittsburg by the Westinghouse Machine Company. The curves for the Bliss turbine were plotted from twenty-four tests

made at Stevens Institute by Prof. F. L. Pryor. The curves for the Kerr turbine were plotted from tests made by the Kerr Turbine Company in their testing plant at Wellsville, N. Y.

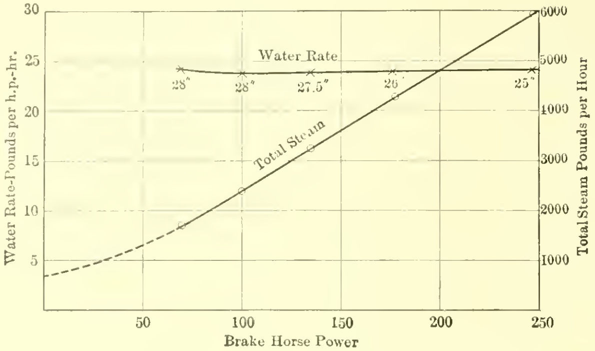

FIG. 30 STEAM CONSUMPTION CURVES, 24-IN. KERR TURBINE

SIX-STAGE, CONDENSING, VARYING VACUUM, 70-LB. PRESSURE-GAGE

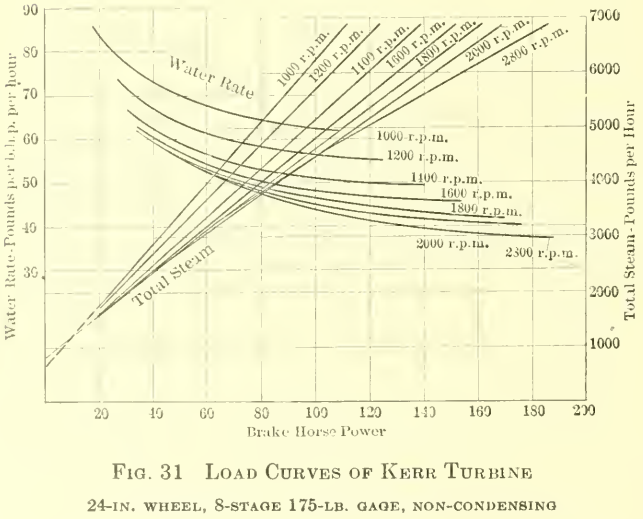

FIG. 31 LOAD CURVES OF KERR TURBINE

24-IN. WHEEL, 8-STAGE 175-LB. GAGE, NON-CONDENSING

32 There seems to be no change in steam economy use. It may be too early to make this statement, but machines running regularly for three years have shown no increase in steam consumption.

33 The field of the small steam turbine is somewhat narrow when

compared with the high-speed steam engine. The small turbine has its place, however, and with the development of a more economical machine at the lower speed ranges, will have a much wider field. The turbine-driven centrifugal fan, for both high and low pressures, will have an increasing use, and the centrifugal turbine-driven pumps have marked advantages over reciprocating apparatus because of the absence of shock on the pipe line and their adaptation to space conditions.

34 The promise of development on these lines has led many manufacturers to enter the small-turbine field and the great expansion of the large-turbine business without doubt presages a like future for the small steam turbine.

OPERATION OF A SMALL PRODUCER GAS-POWER PLANT

By C. W. Obert, New York
Associate Member of the Society

It has been the practice of the packing house of Swift & Company of Chicago, in the distribution of meats and provisions to retailers, to establish in different cities distributing depots with the necessary power equipment for the handling and refrigeration of the products. Some of these branches in the larger cities are establishments of considerable size, and with the extensive cold storage facilities required for the large stocks carried, require comparatively large power installations. The new Westchester market, which the company has recently built in New York at 152d Street and Brook Avenue in the Bronx, is a notable installation of this kind, involving a 400-h.p. producer gas-power plant for the operation of both refrigerating and electric generating machinery, which supplies similar service to a number of adjoining depots of other houses.

2 The refrigerating duty at present required embraces the operation of a total cooling system containing over 46,000 ft. of 2-in. pipe, which reaches a maximum of over 100 tons of refrigeration per 24 hours under the most severe summer weather conditions. Two 65-ton refrigerating machines were installed for this service, with equipments in duplicate, owing to the great importance of continuity of refrigeration, particularly in hot weather. A maximum of nearly 90 h.p. is required for compression machines of this size and engines of 100 h.p. were selected for driving them, to provide sufficient capacity for unfavorable or overload conditions.

3 The electrical load, which includes the operation of several electric elevators, fluctuates ordinarily between 30 kw. and 50 kw. but occasionally reaches a maximum of over 60 kw. For this service, duplicate 75-kw. generators were installed, with driving engines of 100

To be presented at the Washington Meeting (May 1909) of The American Society of Mechanical Engineers. All papers are subject to revision.

h.p. This was done to secure uniformity of size and detail in all four of the driving-engines.

4 For gas making, two producer equipments were installed, also in duplicate. One of these is a 200-h.p. producer, intended for the supply of one refrigerating machine and one generator engine when operating at maximum capacity. The other is of 150-h.p. capacity to permit of closer adjustment of the producer capacity to the load at other times.

5 The plant arrangement consists of an engine room in the easterly end of the sub-basement of the market building, and a producer room adjoining, the entire power equipment occupying a total space, including fuel storage, of 48 ft. by about 55 ft. Headroom for the machinery and piping is afforded by the depression of the sub-basement floor to a level 16 ft. below the street, and the omission of the basement floor in this section, giving thus a clear headroom of 18 ft. The machinery space was originally laid out as a single room, but as a result of the requirements of the underwriters, the producer space has been separated from the rest by a 6-in. hollow-tile fire wall, forming a a producer room 20½ ft. by 24 ft. maximum dimensions. Under the 152d Street sidewalk, there is an 11 ft. by 29 ft. room containing pumps and auxiliaries for the power equipment and the building heater; and adjoining this, an 11 ft. by 30 ft. space for fuel storage. The latter has capacity for over 150 tons of coal, which is dumped into it through sidewalk coalholes from wagons in the street.

6 The engines are Rathbun vertical, three-cylinder units, of 100 h.p., rated at 280 r.p.m., built by the Rathbun-Jones Engineering Company, Toledo, Ohio. The two for the electrical service are direct-connected to 75-kw. generators and the other two through silent chain drives to the ammonia compressors of the refrigerating equipment. They are all of the four-stroke cycle, single-acting, enclosed type, and have 12¾ in. by 13-in. cylinders, designed for the above rating when operating on producer gas of not less than 125 B.t.u. per cu. ft. These engines are throttle-governed, a special form of centrifugal flyball governor being used, and have each a one-ton fly-wheel at both ends of the crankshaft.

7 The gas is generated for the engines in a duplicate equipment of Smith suction producers built by the Smith Gas Power Company, Lexington, Ohio. Each equipment consists of a simple shell producer, a wet scrubber and a dry purifier. While the producers differ in rated capacity to permit of more accurate adjustment of their capacity to the power requirements at different seasons of the year.

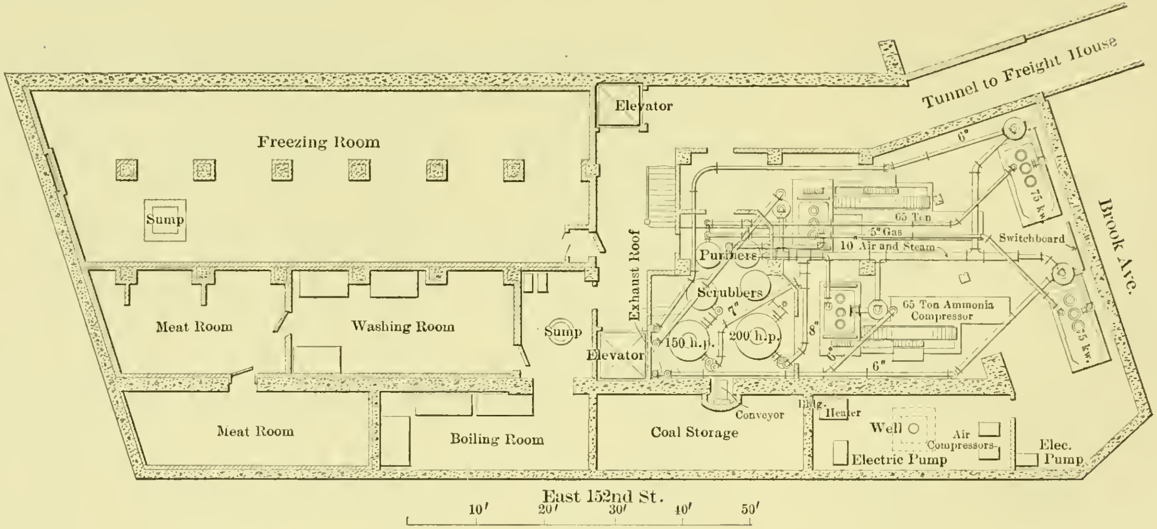

Fig. 1 Plan Showing Location of Machinery, Apparatus and Connections

the scrubbers and purifiers have a maximum capacity of 200 h.p., which permits the smaller producer to operate up to the maximum plant capacity of 200 h.p., if required to do so temporarily. The small and large producers have 6-ft. and 7-ft. shells respectively, both 12 ft. in height, their internal diameters being 4½ ft. and 5½ ft. respectively, and they are fitted with shaking grates on the up-draft principle for operation with anthracite coal. They are not fitted with attached vaporizers or air pre-heaters, but have an automatic control attachment for regulation of the amount of water vapor to conform to the power requirement and consequent rate of gasification. The scrubbers for cleansing the gas are vertical cylindrical tanks, each 4 ft. in diameter by 15 ft. high, and the dry purifiers have 4-ft. shells 6 ft. in height.

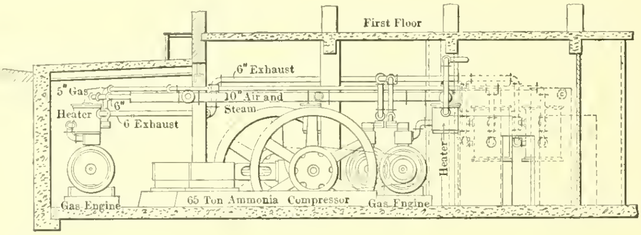

Fig. 2 Elevation of Machinery Room in Cross-Section

8 The piping of the plant was somewhat involved by the arrangement of the engines relative to the producers, and, in the Smith producers system, by automatic vaporizers in the exhaust connections to utilize the waste heat of the engines for the vaporization of the water. The vaporizers are located close to the engines and attached to each vaporizer is an automatic device, through which air is admitted and superheated for the producer. The air is conducted to the producers from these devices by a 10-in. pipe main, extending through the engine room, and heavily covered with magnesia insulation.

9 The gas is delivered from the producers by 8-in. pipes connecting from the top of the producer to the bottom of the scrubber shell and each scrubber has a triplicate connection to its corresponding purifier, which is a three-part filter. From these the gas is conducted to the engines through a 5-in. line, with a 3½-in. branch to each. The exhaust connections from the engines to the vaporizers are 5-in. lines and from the latter, individual discharge pipes are carried up for each engine through a pipe shaft in the corner of the building to a roof outlet.

It is to be noted that this arrangement of exhaust connections is effective in so muffling the noise of the escaping gases that they cannot be heard from the adjoining street and are only barely noticeable when on the roof close to the outlets.]

10 The electrical generators are 75-kw. General Electric direct-current machines, each rigidly coupled to the driving engine. They are wound to deliver current at 220 volts, the distribution for both lighting and power being on the two-wire system. The electrical circuits are controlled on a three-panel switchboard which contains the usual equipment of indicating and recording instruments, field-rheostat switches and generator and feeder switches. The building is wired separately for lighting and power circuits, and recording watt meters are connected into the feeder circuits for measurement of the power delivered. It is to be noted that separate bus bars are provided for both power and lighting feeders, as well as a switching arrangement by which the lighting service may be supplied from a generator other than that carrying the power load, in case the fluctuations of the latter should interfere with the voltage regulation. This provision has been found unnecessary, however, as the speed regulation of the engines and generators is satisfactory under all fluctuations of loading due to elevator operation.

11 The refrigerating equipment was installed on the direct ammonia expansion system, a feature of which is the connection of all coils in the coolers in series with those in the freezers, whereby all ammonia not thoroughly evaporated in the freezer coils will be in the cooler coils (temperature, 36 deg. fahr.), which permits carrying the freezer temperature at from 0 deg. to + 5 deg. without frosting the compressor. The compressors were built by the Hutteman & Cramer Company, Detroit, Mich., and are horizontal single-cylinder double-acting machines, with 14 in. by 30-in. cylinders, each driven at a speed of 60 r.p.m. by a Renold silent-chain connection from its driving engine, with a speed reduction of about five to one.

12 The ammonia condenser is located on the roof of the building and provided with the usual water-cooling sprays. The water supply for it is obtained from a well extending into water-bearing soil under the basement floor, and the drainage from the sprays is subsequently utilized in the scrubbers and in the engine cylinder jackets. One of the compressor units normally handles the load alone, which leaves one equipment always in reserve, to provide against the serious emergency of a complete stoppage of the refrigerating service during hot weather.

13 In operation this plant has proved particularly economical, largely due to the continuous character of the service resulting from the operation of the refrigeration plant 24 hours a day, seven days a week, thereby eliminating standby losses. The average load range of the plant is ordinarily from 50 per cent (100 h.p.) to full rated load (200 h.p.), the high and low load factors occurring during the summer and winter months respectively, when the refrigeration requirements are maximum and minimum. With the heavier load factor during the summer months, the fuel consumption has ranged between 3400 and 4800 lb. per 24 hours, the larger figure having been exceeded on only two days in 11 months, and the consumption per horsepower-hour as calculated from station fuel records and observed loads, ranged from 1.4 to 2.0 lb. of coal. The fuel rate has dropped during periods of continuous high loads, to about 1 lb. per horsepower-hour, as based on observed loadings, but the daily average under conditions of ordinary commercial operation is usually greater.

14 The operating conditions during the heavy-load season are indicated in the table at the end of the paper, in which the relation of fuel consumption to load carried is shown for two weeks of similar duty. The variations in the amount of fuel charged from day to day are due chiefly to the differing conditions of the fuel bed in the producer, the removal of a particularly large amount of ashes on any day necessitating a heavy fuel charge. No account is taken of cost of water used in the scrubbers and cooling jackets, as the supply is obtained from a well on the premises without cost other than that of pumping.

15 The fuel used is No. 1 buckwheat anthracite that has been passed over a $\frac{3}{8}$-in. mesh and through a $\frac{9}{16}$-in. mesh screen, with 5 per cent fineness, and costs $3.50 per gross ton delivered in cargo lots. It is charged only at the regular cleaning periods, at each of which from 400 to 900 lb. of coal are fed, after the fire has been cleaned down and the ashes removed from the grate. The fire is cleaned periodically twice every shift, or four times per 24 hr. and requires about an hour per cleaning on the average.

16 In this connection it is interesting to note the comparatively short time required to start a producer into service from the cold, which has been done repeatedly on short notice in about five hours; on December 12 when the 150-h.p. producer was placed in operation to relieve the larger unit, the kindling wood was lighted at 10 a.m. and the gas supply turned onto the engine at 2 p.m., with only about 12-in. of fire zone in the fuel bed. The reliability of a suction producer

operating under a continuous and exacting service of this character is well shown by the duty of the 200-h.p. producer during the summer season of 1908, which when taken out of service on December 12, had been continuously in service 24 hours per day and seven days per week since April 22, a continuous run of 235 days. During that time, it had received no more attention than the four cleanings and chargings per 24 hours.

17 The operating force for the power plant consists of an engineer and an assistant engineer and two producer tenders, who work in two shifts. This force is able to maintain the plant equipment in satisfactory operating condition, as well as the refrigerating and electrical equipment of the depot, and it is worthy of note that the plant has not been shut down for any reason since it was started on February 1, 1908. Experience gained in operation for this period indicates that, contrary to the general opinion, no more attention is required than for a first-class steam plant, the necessary attendance comparing very favorably with that of a high-grade steam plant of the same capacity. Cleanliness of all parts of both producer and engine equipments, and careful adjustments, especially of the latter, are imperative and are the keynotes of successful operation. In order to maintain the equipment in such condition, a thorough and comprehensive operating system has been developed which may be of interest.

18 The operating system involves a detailed and thorough inspection routine that keeps the force well informed as to the condition of the entire equipment and a division of duties tending to favor the maintenance work. To the day operating force is assigned the inspection and adjustments of the engines and repairs to igniters, batteries, etc., while the night force has the work of cleaning all machinery.

19 The regular routine of the day force is in detail as follows: First upon coming on duty at 7 a.m., an examination is made of all moving parts of the two engines in operation, and also of oil levels in lubricators and conditions of water jackets and ignition systems. There are always two engines in operation, one being a generator engine and the other a refrigerating engine, which in the periods of heavier loadings in summer time have a combined load of about 140 h.p. of which fully 75 h.p. is taken by the refrigerating system. Next the water regulation for the steam supply is noted and then the condition of the suction draft on the producer and also on the scrubber and purifier, there being three U-shaped draft gages provided for this purpose, one connected to the gas suction line to the engines, the

second to the gas connection from the scrubber to the purifier and the third to the connection between the producer and scrubber. A uniformity of suction of from 2 in. to 3 in. of water in these three gages indicates a proper condition of the three units, while any unusual suction in any of the connections would indicate an obstruction needing immediate attention. The latter is always clearly indicated as an obstructed condition in the producer, for instance, will raise the suction to as high as 9 in. or 10 in. of water.

20 Next an inspection is made of the producer, the temperatures of different portions of the fire being determined to ascertain the condition of the fuel bed, the existence of cracks or fissures or pockets of unburned coal. To do this, a $\frac{5}{16}$-in. iron rod is pushed into the fire through the side peep holes in the producer shell, held there exactly one minute and then withdrawn, the temperature within being noted from the color of the rod. If the latter is at a uniform cherry red temperature throughout its length, this is taken as an indication of an even fire; but if at a brighter heat or dull in some portions of the rod, there is evidence of unnecessarily high local temperatures due to rapid combustion in fissures in the fuel bed, or of a stagnant condition in dirty or unburnt portions of the fire. The rod is first inserted in the lowest hole and then successively into the upper holes, in order to explore the fire in zones. On withdrawing the rod the operator notes graphically the condition of the fire by marking a line with chalk on the shell of the producer even with the hole, a straight line indicating an even temperature, and a broken line showing the dirty condition, etc. This operation is continued for the four holes and a fuel curve drawn from it which gives a practical idea of how the dirt lies in the producer and shows what quality of gas can be expected. Finding the producer in good order, the scrubber, purifier and connections are examined for unusual temperatures, condition of water flow, etc.

21 In the maintenance work, each engine is shut down after every seven days work of 160 hours for general inspection and cleaning, and thus on Monday mornings it is necessary to start up the two reserve units and transfer the respective loads to them. Before starting up either reserve engine, its igniters are cleaned, which takes about one hour. With the igniters clear and everything in good order, the attendant looks at the draft gage, which is equal in importance to the gage of a steam boiler, to see what gas the engines in operation are drawing and whether the start can be made without interfering with their suction. If there are any doubts the gas is

enriched temporarily by putting about four pails of water in the ash pit of the producer and slicing the fire to work down some hot coals, which, by turning the water into vapor, increase the hydrogen content of the gas and enable the third engine to be started without interfering with the others. After getting the engine warmed up, the load is thrown on and the other engine is shut down. The extra pull on the producer, due to overload from running the three engines and the hydrogen added, has usually so enriched the gas that on cutting out a unit the quality of gas is too rich for the two units operating alone. To counteract this, it is necessary to give additional air to each of the units that remain and then, as in starting, there will be no variation in speed of operation.

22 After the engines have been shut down their inspection is begun by the removal of the back crank case covers and examination of the bearings, crank pins, wrist pins, etc., for necessary adjustments. Besides this the exhaust valves are cleaned and the ignition system checked, which requires about two days, as but one thing is done at a time and then only at times when the load on the plant is not heavy. While the engineer is performing this work, the producer tender prepares to clean and coal the producer, as follows:

23 The method of cleaning is to rake off the ash from the grate table and then poke down around the shell from the top poke holes. Having before him the fuel chart which was noted graphically on the producer shell on coming on watch, the attendant knows what part of the bed requires most poking. Before opening the ash pit doors about the shell, water is placed in the ash pit as before and the hot ashes, dropping down, form sufficient steam to mix with the air coming through the ash pit door and offset any bad effect therefrom. This enables the cleaning to be done without affecting the engines. Having cleaned and poked the fire thoroughly and worked down all the ash so as to leave it as clean as possible, the coaling is then begun, count being taken of each hopper of coal charged. The coal is cleaned by screening if very fine or dirty. Having coaled, the operator slices across the grate so as to relieve the center of the fire and again puts water in the ash pit, this time to cool off the grate after cleaning and to offset the effect of any air that may have gotten in during the operation. The cleaning usually occupies one hour, the amount of coal put in ranging up to 900 lb. After giving the producer time to settle down, the ashes are withdrawn from the ash pit, an average of 1½ ash cans (about 3 bushels) being removed after each cleaning. During the cleaning operation the operator is always on the lookout for any

change in the engine speed due to weak gas on account of opening the ash doors. Should this occur he immediately cuts the air supply to the engine, resulting in a combustible mixture without noticeably reducing the speed. The producer is now good for 6 hours' operation, after which the cleaning is repeated.

24 The refrigerating engines are operated for periods of 84 hours and then gone over. One exhaust valve is taken out of an engine each week, thoroughly cleaned, and reground if necessary, thus insuring attention to each valve once in every three months. Igniters are cleaned weekly and the batteries and ignition system checked. The temperature of the fuel bed of the producer is taken twice a day and a gas analysis is made once a week or oftener if necessary. The average calorific value per cubic foot of gas is 134 B.t.u., based on analysis: CO_2, 8.6 per cent; O, 0.6 per cent; CO, 20.2 per cent; H, 18.5 per cent and N, 52.1 per cent.

TABLE 1 RECORD OF LOAD AND FUEL FOR TWO HEAVY WEEKS

	ELECTRICAL LOAD		Refrigerating Load	Total Load	Coal Charged Pounds
	Kw hours[1]	B.h.p. hours[2]	B.h.p. hours	B.h.p. hours	
Sunday, July 25, 1908	332	556	2010	2566	3600
Monday, July 26	400	600	2030	2630	3900
Tuesday, July 27	404	606	2020	2626	3540
Wednesday, July 28	390	585	2020	2605	3180
Thursday, July 29	410	615	2030	2645	4020
Friday, July 30	415	622	2040	2662	4320
Saturday, July 31	403	605	2020	2625	4080
Sunday, August 22, 1908	328	549	2030	2579	3660
Monday, August 23	386	579	2020	2599	3420
Tuesday, August 24	393	589	2020	2609	3600
Wednesday, August 25	392	588	2010	2598	3540
Thursday, August 26	397	596	2010	2606	3840
Friday, August 27	391	586	2020	2606	3540
Saturday, August 28	393	590	2020	2610	3720
Totals	5434	8266	28300	36566	51960

[1] Recorded by watt-hour meters.

[2] Deduced from kilowatt-hours by assuming 80 per cent efficiency for the generator during light-load periods and 90 per cent for the remaining time.

SOME PROPERTIES OF STEAM

By Prof. R. C. H. Heck, New Brunswick, N. J.

Member of the Society

The purpose of this paper is to present some recent experimental results as to two of the fundamental thermodynamic properties of water and steam, and to make certain comparisons between these determinations and the older values used in our steam tables. The two properties considered are, the relation between pressure and temperature of saturated steam, and the specific heat of water.

THE PRESSURE-TEMPERATURE RELATION

2 This relation is, from the point of view of experimental determination, the simplest of the properties of steam, and with accurate instruments and adequate skill can be very precisely measured. For this reason, the results obtained by various experimenters differ by relatively small amounts, and in discussing them we take up a question in the realm of scientific accuracy rather than one concerning effectively correct values for ordinary technical use. For certain purposes, however, it is most important that this relation be truly and accurately known.

3 In *Annalen der Physik*, 1907, vol. 22, p. 609 to 630, is published a paper by F. Henning, On the Saturation Pressure of Steam, in which are gathered together all the determinations that have been made on this relation, from Magnus and Regnault down to that time. These are compared by means of curves, which show, to a large scale, their departures from an assumed standard of reference. This standard is the formula of Thiesen,

$$(t + 273) \log \frac{p}{760} = 5.409\,(t - 100) - 0.508 \times 10^{-8}\,[(365 - t)^4 - 265^4]$$

where t is centigrade temperature and p is pressure in millimeters of mercury. From the comparison and discussion the conclusion was reached that up to 100 deg. cent. this formula is to be accepted, while above 100 deg. the determinations of Regnault are best—not as

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set forth by his formula, but as worked over by Henning, from a selection of his more reliable observations.

4 A new and very accurate determination by Holborn and Henning, over the range from 50 deg. to 200 deg. cent., is fully described in *Annalen der Physik,* 1908, vol. 26, p. 833 to 883, in a paper, On the Platinum Thermometer and the Saturation Pressure of Steam, while in *Zeitschrift des Vereins deutscher Ingenieure,* February 20, 1909, is given a brief presentation and comparison of results. Exceedingly close agreement is shown between these new observations, the recomputed Regnault values, and the work of Knoblauch, Linde, and Klebe —see Table 3 in *Zeitschrift* article. The final result is a table giving p for every degree from 0 deg. to 205 deg. cent., which follows Thiesen's formula up to 50 deg., and embodies the authors' work from that point.

5 This table is here reproduced in Table 1, but with pressure converted to pounds per square inch and interpolated for every degree fahrenheit from 32 deg. to 402 deg., or to just past 250 lb. abs. Later the writer hopes to extend this table, carrying forward the line of the Holborn-Henning determination in comparison with the observations of Regnault and others. This can be done even up to a pressure of 1000 lb. with sufficient accuracy for all practical purposes.

6 In the work of conversion and interpolation, it was necessary to carry the numbers to a higher degree of apparent accuracy, or to use more significant figures, than any experimental precision would call for. Without a mathematical formula, a function of this sort can be carried forward only by carefully smoothing out the differences until those of the second order follow a continuous rate of change. In this operation, the first differences were brought to a sufficient degree of smoothness to furnish effectively accurate values of the rate of change of p with t; and this differential coefficient, $\frac{dp}{dt}$ is also given in Table 1. It may be considered absolutely correct (as a derivative) within about four or five units in the last place, while as between successive values the closeness is much better. This is less precise than might be desired, but it is accurate enough for use in calculating specific volume, since the thermal data there involved are not of any greater degree of reliability.

7 In Fig. 1 is given a comparison between the pressures in Table 1 and some hitherto generally used values. The base is temperature fahrenheit, the ordinate the difference between the other value of p and that in Table 1. Curve 1, for the range up to 225 deg. fahr., is

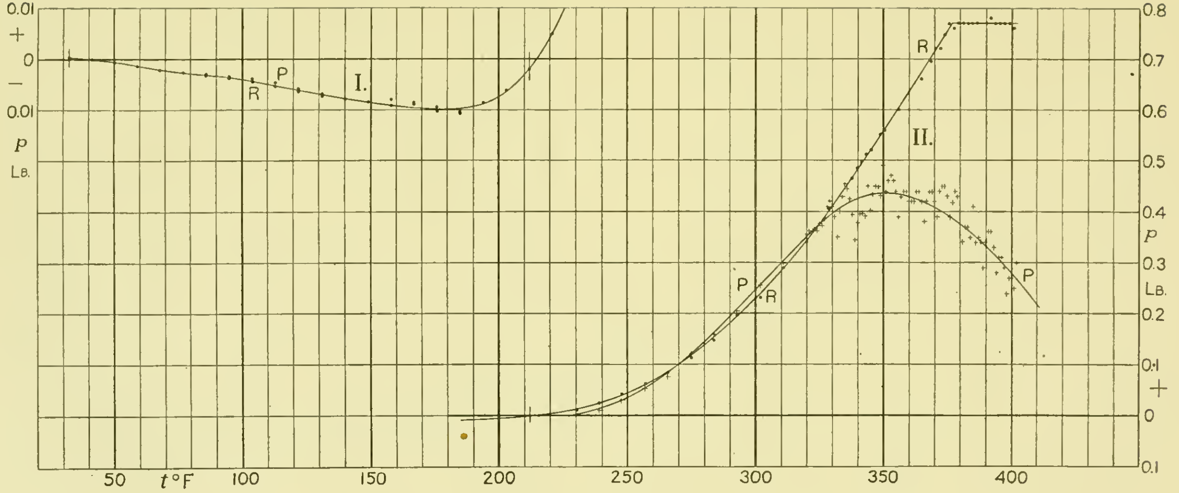

Fig. 1 Comparison of Pressure-Temperature Determinations

Diagram shows departure of Regnault (R) and Peabody (P) values of the pressure p from those of Holborn and Henning, as given in Table 1 drawn to the large scale at the left, and shows how Regnault's formula drops below the new determination. The curves at 2 have the ordinate scale at the right, only one-tenth as large as that for 1. The letter R marks the "standard" Regnault curve, here plotted from the table in Roentgen's Thermodynamics, which happened to be the most convenient in its manner of expression: note the abrupt change at about 380 deg. fahr. Curve P shows Peabody's values, which are based on Regnault, but with revised computations, and depart quite decidedly from the older table above 325 deg. The scattering of the points above that temperature is due to the coarseness of numerical expression, Peabody giving but one decimal place for the higher pressures. The curve is simply sketched through this band of points.

8 Holborn and Henning do not attempt to devise a formula, but base their table on a method of graphical interpolation. It will be noted that Curve 1 shows a faint waviness, indicating some departure from perfect mathematical smoothness; but the extreme smallness of the irregularities is really a proof of the skill with which the original interpolation was made.

THE SPECIFIC HEAT OF WATER

9 In Fig. 2 are plotted several important curves for the specific heat of water—the true or instantaneous, not the mean value. Curve R shows Regnault's formula, which in fahrenheit units is,

$$c = 1 + 0.0000222\ (t - 32) + 0.00000278\ (t - 32)^2$$

This curve differs radically from the newer and true determination of the specific heat over the lower part of the range, as shown by the other curves.

10 Curve B represents the experiments of H. T. Barnes and associates; these are described briefly in *Proceedings Royal Society*, 1900, vol. 67, fully in *Phil. Trans. Roy. Soc.*, 1902, vol. A 199; while in *Physical Review*, 1902, vol. 15, there is a description of the determination on supercooled water, which was carried to −5 deg. cent., and the tabulated values for the whole range up to 95 deg. cent. The body of this work was done by a continuous method, water flowing through a small tube and absorbing heat which was electrically supplied and measured: for the range below freezing, a method of mixing was found necessary.

11 Curve P, which begins at 140 deg. fahr., shows the values used by Peabody above this temperature; below it he accepts the work of Barnes. Peabody's line—it is almost straight—is based on Reg-

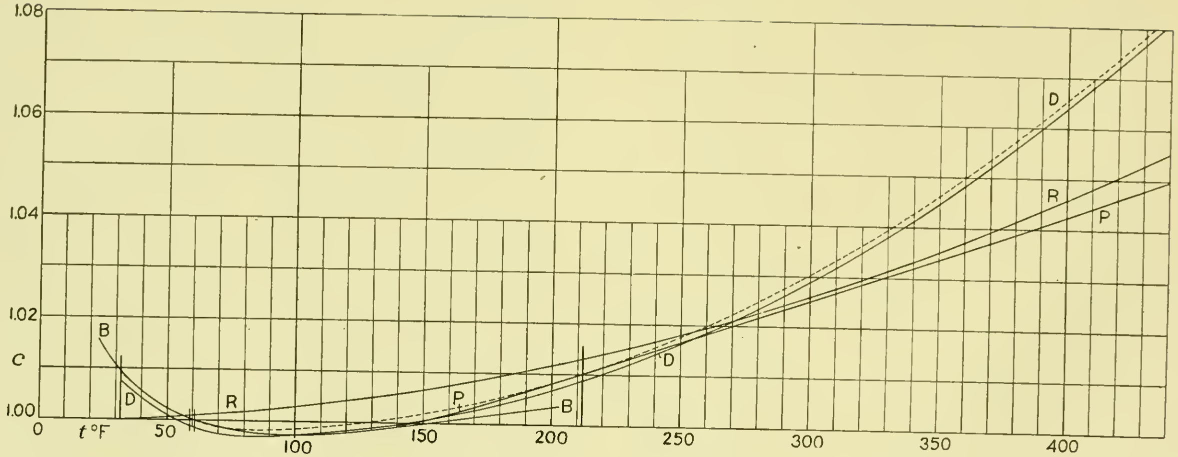

FIG. 2 THE SPECIFIC HEAT OF WATER, VALUES MEASURED OR USED BY REGNAULT (*R*), BARNES (*B*), PEABODY (*P*), AND DIETERICI (*D*)

THE LAST ARE IN MEAN CALORIES; CONVERSION TO THE 15-DEG. CENT. CALORIE RAISES THE *D* CURVE TO THE DOTTED POSITION nault's experiments: but it hardly seems reasonable to make c thus an almost straight-line function of t.

12 Curve D shows the very important experiments of Dieterici, described in *Annalen der Physik,* 1905, vol. 16. In these a small body of water, pure and free from air, was sealed in a tube of quartz. This little cartridge was heated to a certain desired temperature, then dropped into a Bunsen ice calorimeter, where the heat given off in its cooling to 0 deg. cent. is measured. The highest temperature reached was about 300 deg. cent. The drawback in this method is the relatively large heat capacity of the quartz tube, which has to be very carefully determined. From 100 deg. fahr. upward, Dieterici finds that his results conform very well to a parabolic equation like that of Regnault, which for fahrenheit units has the constants,

$$c = 0.99827 - 0.0000576\ (t - 32) + 0.00000064\ \ (t - 32)^2$$

Below 100 deg. fahr., tabulation from graphical interpolation is preferable to expression by formula. A numerical comparison of the several curves is given in Table 2.

DIFFERENT HEAT UNITS

13 Before discussing these data, something must be said as to the unit of heat measurement. Regnault intended to use the heat capacity of water at 15 deg. cent. as the heat unit—in other words, the 15-deg. calorie—but it was not until long after his time that the true manner of variation of the specific heat over the lower range of ordinary temperatures was either clearly perceived or accurately measured. Barnes' values are based on unity at 16 deg. cent., and it will be noted that the B curve on Fig. 2 crosses the base-line at just about 16 deg. cent. (the two short vertical cross-lines near 60 deg. fahr. are at 15 deg. and 16 deg. cent.). The now generally used numerical values of the mechanical equivalent of heat, 427 m-kg. or 778 ft. lb. are based on a heat unit at 15 deg. cent or 59 deg. fahr.

14 Dieterici's results are expressed in the mean calorie, which is one one-hundreth of the heat required to raise 1 kg. of water from 0 deg. to 100 deg. cent.; and his specific heat values check up to an average of unity over this range. Graphically, on Fig. 2, his curve cuts the 15-deg. cent. ordinate at 0.0012 below the unity base-line. In a special experiment, with electrical measurement analogous to that used by Barnes, he made the mechanical equivalent of the mean calorie bear to our standard Rowland value for the 15-deg. calorie the

ratio of the numbers 419.25 to 418.8, or 1.0011 to 1.000,00. Disregarding some uncertainties which may exist in the minds of physicists as to the finality of this determination, it seems reasonable, for engineering purposes, to use this 0.0011 or 0.11 per cent correction in order to change from one system of units to the other.

15 The amount of attention here paid to this small point is justified by the importance given to it through the introduction of the mean calorie to the Society in the recent paper on The Total Heat of Saturated Steam, by Dr. H. N. Davis. Personally, I think we had better transform heat values in this unit by means of the ratio just offered, rather than change our mechanical equivalent of heat from 778 to 778.9.

16 Now the specific heat is the ratio of a certain absolute quantity of heat to an assumed unit quantity. If we use a larger unit, the ratio will be smaller, and *vice versa.* Assuming that the mean calorie is 1.0011 of the 15-deg. calorie, we change Dieterici's values to the 15-deg. unit if we increase them by 0.11 per cent. This would raise his curve to the dotted position on Fig. 2, and change his formula to

$$c = 0.99938 - 0.00005766 \ (t - 32) + 0.0000006407 \ (t - 32)^2$$

SPECIFIC HEAT OF WATER—CONCLUSION

17 It is pretty safe to say that the Holborn-Henning results for pressure and temperature, set forth in Table 1, are final, and that this relation is now known surely and accurately enough for all purposes of practical science. But in regard to the specific heat of water we are yet confronted by one of the annoying uncertainties which have so long surrounded many parts of this subject. Dieterici claims an experimental accuracy ranging from 0.1 per cent at low ranges to 0.5 per cent at high ranges of temperature: but his method is open to the objection that two heat-capacities have to be measured and their difference used.

18 In spite of some small doubt as to the accuracy of Dieterici's results, and a faint suspicion that his curve may rise too rapidly, I am of the opinion that his determination is to be accepted instead of Regnault's. Further, the idea of an increasing rate of increase in c, as expressed by a second-degree equation, seems to be far more reasonable than that of a nearly constant rate of increase.

19 It is hardly probable that the heat capacity of water will ever be so accurately determined that the heat for the external work of expanding the water will be more than a small fraction of the probable error in heat measurement.

TABLE 1 THE PRESSURE-TEMPERATURE RELATION

t	p	dp/dt	t	p	dp/dt	t	p	dp/dt	t	p	dp/dt
....	....	.....	76	0.4433	0.01467	121	1.7362	0.04815	166	5.459	0.1277
32	0.0886	0.003575	77	0.4582	0.01510	122	1.7849	0.0493	167	5.588	0.1302
33	0.0922	0.00371	78	0.4735	0.01554	123	1.8348	0.0505	168	5.719	0.1327
34	0.0960	0.003845	79	0.4893	0.01600	124	1.8859	0.0517	169	5.853	0.1353
35	0.0999	0.003985	80	0.5055	0.01646	125	1.9382	0.05295	170	5.990	0.1380
36	0.1039	0.00413	81	0.5222	0.01694	126	1.9918	0.0542	171	6.129	0.1407
37	0.1081	0.00428	82	0.5394	0.01742	127	2.0466	0.05545	172	6.271	0.1434
38	0.1125	0.00443	83	0.5570	0.01792	128	2.1027	0.05675	173	6.416	0.1462
39	0.1170	0.004585	84	0.5752	0.01844	129	2.1601	0.0581	174	6.564	0.1490
40	0.1217	0.004745	85	0.5939	0.01898	130	2.2189	0.05945	175	6.714	0.1519
41	0.1265	0.00491	86	0.6132	0.01952	131	2.2790	0.0608	176	6.868	0.1548
42	0.1315	0.005075	87	0.6330	0.02008	132	2.3405	0.06215	177	7.024	0.1577
43	0.1367	0.00525	88	0.6533	0.02065	133	2.4033	0.06355	178	7.183	0.1607
44	0.1420	0.00543	89	0.6743	0.02123	134	2.4675	0.06495	179	7.345	0.1637
45	0.1475	0.00561	90	0.6958	0.02182	135	2.5332	0.06645	180	7.511	0.1668
46	0.1532	0.00580	91	0.7179	0.02243	136	2.6004	0.0680	181	7.679	0.1699
47	0.1591	0.00600	92	0.7406	0.02305	137	2.6692	0.0696	182	7.850	0.1730
48	0.1652	0.00620	93	0.7640	0.02368	138	2.7396	0.0712	183	8.025	0.1762
49	0.1715	0.00641	94	0.7880	0.02432	139	2.8116	0.0728	184	8.203	0.1794
50	0.1780	0.00663	95	0.8127	0.02498	140	2.8851	0.0744	185	8.384	0.1827
51	0.1847	0.00685	96	0.8380	0.02566	141	2.9603	0.0760	186	8.568	0.1860
52	0.1917	0.00708	97	0.8640	0.02635	142	3.0371	0.0776	187	8.756	0.1894
53	0.1989	0.00731	98	0.8907	0.02705	143	3.1155	0.0793	188	8.947	0.1929
54	0.2063	0.00754	99	0.9181	0.02776	144	3.1956	0.0810	189	9.142	0.1964
55	0.2104	0.00778	100	0.9462	0.02849	145	3.2775	0.0828	190	9.340	0.1999
56	0.2219	0.00803	101	0.9751	0.02923	146	3.3612	0.0846	191	9.542	0.2035
57	0.2301	0.00829	102	1.0047	0.02999	147	3.4467	0.0864	192	9.747	0.2072
58	0.2385	0.00856	103	1.0350	0.03077	148	3.5341	0.0883	193	9.956	0.2109
59	0.2472	0.00883	104	1.0662	0.03157	149	3.6233	0.0902	194	10.169	0.2147
60	0.2561	0.00911	105	1.0982	0.03240	150	3.7141	0.0921	195	10.385	0.2185
61	0.2653	0.00939	106	1.1310	0.03325	151	3.808	0.0940	196	10.606	0.2224
62	0.2749	0.00968	107	1.1647	0.0341	152	3.903	0.0960	197	10.830	0.2263
63	0.2847	0.00998	108	1.1992	0.0350	153	4.000	0.0980	198	11.058	0.2303
64	0.2948	0.01029	109	1.2347	0.0359	154	4.099	0.1001	199	11.291	0.2343
65	0.3053	0.01061	110	1.2711	0.03685	155	4.200	0.1022	200	11.527	0.2384
66	0.3161	0.01094	111	1.3084	0.03775	156	4.303	0.1043	201	11.767	0.2425
67	0.3272	0.01127	112	1.3466	0.0387	157	4.408	0.1064	202	12.013	0.2467
68	0.3386	0.01161	113	1.3858	0.0397	158	4.516	0.1086	203	12.261	0.2509
69	0.3504	0.01196	114	1.4260	0.0407	159	4.625	0.1108	204	12.514	0.2552
70	0.3625	0.01232	115	1.4671	0.0417	160	4.737	0.1131	205	12.771	0.2595
71	0.3750	0.01269	116	1.5093	0.0427	161	4.852	0.1154	206	13.033	0.2639
72	0.3879	0.01307	117	1.5525	0.04375	162	4.968	0.1178	207	13.299	0.2683
73	0.4012	0.01345	118	1.5968	0.0448	163	5.087	0.1202	208	13.569	0.2728
74	0.4148	0.01384	119	1.6421	0.0459	164	5.209	0.1227	209	13.845	0.2783
75	0.4289	0.01425	120	1.6886	0.0470	165	5.332	0.1252	210	14.124	0.2819

TABLE 1.—Continued

t	p	dp/dt	t	p	dp/dt	t	p	dp/dt	t	p	dp/dt
211	14.408	0.2866	256	33.085	0.5677	301	67.99	1.015	346	127.67	1.675
212	14.697	0.2914	257	33.657	0.5758	302	69.01	1.027	347	129.35	1.693
213	14.991	0.2962	258	34.236	0.5840	303	70.05	1.0395	348	131.05	1.711
214	15.290	0.3011	259	34.824	0.5922	304	71.09	1.052	349	132.77	1.729
215	15.594	0.3061	260	35.420	0.6005	305	72.15	1.065	350	134.51	1.746
216	15.902	0.3111	261	36.025	0.6088	306	73.22	1.0775	351	136.26	1.764
217	16.215	0.3162	262	36.638	0.6172	307	74.31	1.090	352	138.04	1.782
218	16.534	0.3214	263	37.259	0.6256	308	75.40	1.103	353	139.83	1.800
219	16.858	0.3266	264	37.888	0.6341	309	76.51	1.116	354	141.64	1.818
220	17.187	0.3319	265	38.526	0.6426	310	77.64	1.129	355	143.46	1.836
221	17.521	0.3372	266	39.173	0.6513	311	78.77	1.142	356	145.31	1.855
222	17.860	0.3426	267	39.828	0.6600	312	79.92	1.155	357	147.17	1.874
223	18.205	0.3480	268	40.492	0.6688	313	81.08	1.169	358	149.06	1.893
224	18.556	0.3535	269	41.165	0.6777	314	82.26	1.182	359	150.96	1.912
225	18.913	0.3591	270	41.848	0.6868	315	83.44	1.195	360	152.88	1.931
226	19.275	0.3648	271	42.54	0.6960	316	84.65	1.209	361	154.82	1.951
227	19.643	0.3705	272	43.24	0.7052	317	85.86	1.223	362	156.78	1.970
228	20.017	0.3763	273	43.95	0.7145	318	87.09	1.237	363	158.76	1.990
229	20.396	0.3821	274	44.67	0.7239	319	88.34	1.251	364	160.76	2.010
230	20.781	0.3880	275	45.40	0.7334	320	89.60	1.265	365	162.78	2.029
231	21.172	0.3940	276	46.14	0.7430	321	90.87	1.280	366	164.82	2.049
232	21.568	0.4000	277	46.88	0.7527	322	92.16	1.295	367	166.88	2.069
233	21.970	0.4061	278	47.64	0.7625	323	93.46	1.309	368	168.96	2.089
234	22.379	0.4123	279	48.41	0.7725	324	94.78	1.324	369	171.06	2.108
235	22.794	0.4185	280	49.19	0.7826	325	96.17	1.339	370	173.18	2.128
236	23.216	0.4248	281	49.98	0.7926	326	97.45	1.354	371	175.31	2.148
237	23.644	0.4312	282	50.77	0.8028	327	98.81	1.369	372	177.47	2.168
238	24.079	0.4377	283	51.58	0.8131	328	100.19	1.384	373	179.65	2.189
239	24.520	0.4442	284	52.40	0.8235	329	101.58	1.400	374	181.85	2.210
240	24.967	0.4508	285	53.23	0.8340	330	102.99	1.415	375	184.07	2.231
241	25.421	0.4575	286	54.07	0.8446	331	104.41	1.430	376	186.31	2.252
242	25.882	0.4643	287	54.92	0.8553	332	105.85	1.445	377	188.58	2.274
243	26.350	0.4711	288	55.78	0.8661	333	107.30	1.461	378	190.86	2.296
244	26.825	0.4780	289	56.65	0.8770	334	108.77	1.477	379	193.17	2.318
245	27.307	0.4850	290	57.53	0.8880	335	110.26	1.493	380	195.50	2.341
246	27.795	0.4920	291	58.42	0.8991	336	111.76	1.509	381	197.86	2.364
247	28.290	0.4991	292	59.33	0.9103	337	113.27	1.525	382	200.23	2.387
248	28.793	0.5063	293	60.25	0.9216	338	114.81	1.542	383	202.63	2.410
249	29.303	0.5136	294	61.17	0.9330	339	116.36	1.558	384	205.05	2.433
250	29.820	0.5210	295	62.11	0.9445	340	117.92	1.574	385	207.49	2.456
251	30.345	0.5285	296	63.06	0.9561	341	119.50	1.591	386	209.96	2.479
252	30.877	0.5361	297	64.03	0.9678	342	121.10	1.607	387	212.45	2.502
253	31.417	0.5438	298	65.00	0.9796	343	122.72	1.624	388	214.96	2.525
254	31.965	0.5517	299	65.98	0.9915	344	124.35	1.641	389	217.50	2.548
255	32.521	0.5596	300	66.98	1.0035	345	126.00	1.658	390	220.06	2.571

TABLE 1 Continued

t	p	dp/dt	t	p	dp/dt	t	p	dp/dt	t	p	dp/dt
391	222.64	2.594	395	233.20	2.687	398	241.37	2.759	401	249.75	2.832
392	225.24	2.617	396	235.90	2.711	399	244.14	2.783	402	252.60	2.857
393	227.87	2.641	397	238.62	2.735	400	246.93	2.807			
394	230.52	2.664									

TABLE 2 THE SPECIFIC HEAT OF WATER

Temperature		Regnault	Dieterici	Barnes	Peabody
Cent.	Fahr.				
−5	23	....	....	1.0158	....
0	32	1.00000	1.0075	1.0094	....
+5	41	....	1.0037	1.00530	....
10	50	1.00049	1.0008	1.00230	....
15	59	....	0.9987	1.00030	....
20	68	1.00116	0.9974	0.99895	....
25	77	....	0.9970	0.99806	....
30	86	1.00201	0.9971	0.99759	....
35	95	....	0.9972	0.99735	....
40	104	1.00304	0.9974	0.99735	....
50	122	1.00425	0.9983	0.99800	....
60	140	1.00564	0.9995	0.99910	0.99940
70	158	1.00721	1.0012	1.00035	1.00150
80	176	1.00896	1.0032	1.00166	1.00415
90	194	1.01089	1.0057	1.00305	1.00705
100	212	1.01300	1.0086	(1.0044)	1.01010
120	248	1.01776	1.0157	....	1.01620
140	284	1.02324	1.0244	....	1.02230
160	320	1.02944	1.0348	....	1.02850
180	356	1.03636	1.0468	....	1.03475
200	392	1.04400	1.0605	....	1.04100
220	428	1.05236	1.0758	....	1.04760
240	464	(1.06144)	1.0928	....	....
260	500	(1.07124)	1.1115	....	....
280	536	(1.08176)	1.1318	....	....
300	572	(1.09300)	1.1538	....	....

Regnault: from formula, par. 9. Above 200 deg. cent. his formula is an extrapolation.
Dieterici: from table in original publication, computed by formula from 40 deg. cent. upward.
Barnes: from *Physical Review*, with last value extrapolated.
Peabody: from Steam and Entropy Tables, p. 10.
Dieterici: values in mean calories (heat units), others in 15 deg. cent. units.

MARINE PRODUCER GAS POWER

A COMPARISON OF PRODUCER-GAS AND STEAM EQUIPMENTS

By C. L. Straub,[1] New York

Non-Member

So much interest is exhibited both by the engineering profession and the general public in the application of producer gas power to marine, commercial and naval service, that a brief summary of recent progress in this field appears timely.

2 Any innovation which makes for improvement in present practices, surely, though sometimes slowly, achieves its end. Producer gas power, on impartial analysis, offers so many benefits to marine service that it appears strange indeed that more rapid progress has not been made in its adoption. The delay appears to be due to several causes:

3 The marine public, who since the days of the Clermont have exclusively associated the term "motive power" with "steam," have every reason for demanding exact and conclusive evidence of the superiority of gas power or any other power, before adopting it in lieu of their present methods. This evidence is only now slowly coming forth. Many who have been credited with authority by the engineering profession and others, either through ignorance or through being misinformed, have beset the way of marine gas power with numberless imaginary obstacles, ridiculous in proportion to the real difficulties, but sufficient nevertheless to instill some doubt of the possibilities of the system, into the minds of the waiting public.

4 Only recently has such progress been made in the development of gas power for marine work, as to warrant its early adoption in commercial service. Two years ago, less than 300 h.p. in the aggregate was being developed by marine producer gas power installations; these were experimental in nature and were of the German Capitaine

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[1] With the Loomis-Pettibone Co., New York.

To be presented at the Washington Meeting (May 1909) of The American Society of Mechanical Engineers. All papers are subject to revision.

type. There are now installed and accepted 23 Capitaine marine plants, aggregating 2035 h.p., a partial list of which follows:

a Emil Capitaine: Launch, 60 b.h.p.; 4-cylinder single-acting, 4-cycle engine; boat 60 ft. long, 10 ft. beam, 4 ft. deep; ran an average speed of 10 miles for 10 hr. on 412 lb. of anthracite coal.

b Rex: Sea-going Swedish boat; 102 ft. long; 22 ft. beam, carries 350 tons on 9-ft. draft; fitted with a 3-cylinder single-acting, 45-h.p. engine at 300 r.p.m.

c Capitaine: Tow boat at Genoa; length 47 ft., beam 12 ft, draft 7 ft: fitted with a 3-cylinder, single-acting, 4-cycle engine, 105 b.h.p. at 240 r.p.m.

d Duchess: Canal barge; length 71 ft., beam 7 ft. 1 in.; carries 20 tons cargo on 42-in. draft; fitted with double-cylinder, single-acting, 4-cycle engine of 25 b.h.p.

e Dusseldorf: Tug at Hamburg; fitted with a 4-cylinder, single-acting, 4-cycle engine, 60 b.h.p. at 240 r.p.m.

f Isee: Tug, fitted with a 3-cylinder, single-acting, 4-cycle engine, 45 b.h.p., 300 r.p.m.

g Wilhelm: Combination freight and passenger Rhine boat, fitted with a 5-cylinder, single-acting engine, 175 b.h.p. at 240 r.p.m.

h Badenia: Rhine freight boat, fitted with a 2-cylinder, single-acting, 4-cycle engine of 30 b.h.p.

i Katrina: Canal freight boat, fitted with a 3-cylinder, single-acting, 4-cycle engine, 45 b.h.p.

j Marie: Canal freight boat; fitted with a 3-cylinder, single-acting, 4-cycle engine, 45 b.h.p.

k Hoffnung: Combination freight and passenger Rhine boat, fitted with a 5-cylinder, single-acting, 4-cycle engine of 210 b.h.p.

l Amersie: Volga freight boat, fitted with a 4-cylinder, single-acting, 4-cycle engine of 60 b.h.p.

m No. 58: Canal freight boat, fitted with a 4-cylinder, single-acting, 4-cycle engine of 60 b.h.p.

5 In addition to the above there were a number of freight boats, the dimensions and names of which we were unable to obtain, but whose power plants varied in capacity from 30 to 175 h.p. each.

n H. M. S. Rattler: An old gun boat, 165 ft. long, 29 ft. beam, originally fitted with a triple expansion engine. The gas engine is 5-cylinder, single-acting, 4-cycle. Cylinders 20 in. diameter by 24 in. stroke, developing 500 b.h.p. at 120 r.p.m. This engine is started by means of a mixture of gas and air which is pumped into the cylinders at a pressure of about 95 lb. per sq. in. This complete plant was designed entirely in the Capitaine Works at Düsseldorf. The total weight of the entire plant, including the donkey boiler for working the pumps and auxiliaries, is 94 tons, as compared with 150 tons in the case of the displaced steam engine. A consumption of 1525 lb. of coal was made for a measured distance of 45 knots on an average speed of

10½ knots per hr. The cost per mile for fuel with coal at 15*s.* 6*d.* per ton is $0.064 U. S. currency. This boat made a maximum speed of 11.3 knots per hr. against a 1½ knot current at 110 r.p.m. of the engine shaft.

6 All of the above plants by their design and construction are restricted to operation on anthracite coal, coke or hard-burned charcoal, and any plant so restricted by its design to one class of fuel is seriously limited in its scope of application. The development of a simple marine gas-producer for use with any class of solid fuel is a necessity, if the system is to be considered seriously by the marine profession.

7 The writer is fortunate in having been associated with some recent American developments both in stationary and marine gas-power plants, a brief survey of a portion of which will enable us to draw more clearly the comparison between a typical steam and a possible gas installation.

8 There are in commercial operation in this country today, two distinct types of stationary power gas-producers which are suited by their design for operation on almost any class of solid fuel. They may, by their systems of operation, be qualified as up-draft and down-draft producers.

9 In the up-draft producer, the fuel is charged into the generator through an air-tight mechanism at the top, while air and steam, or air and products of combustion are admitted at the bottom of the fuel bed, and passing upward, leave the generator at the top in contact with the fresh fuel. Almost all of the hydro-carbons leave the generator unfixed with the hot gas, only to be condensed later in the gas coolers or scrubbers and gas mains, forming large amounts of tar, which, if not removed to a minute degree, will positively prevent the operation of the engine. The removal of this tar is troublesome and is accomplished at a loss of power and efficiency. The fuel in the upper zone of the bed in the up-draft producers cokes and cakes so seriously as to require continuous poking of the fuel bed, either mechanically or by hand. These features and others in this type of apparatus contribute to limit the rates of combustion per sq. ft. of grate to a relatively low quantity. All things considered, therefore, this type of apparatus has not lent itself agreeably to modification for marine service.

10 In the down-draft type of apparatus, the fuel is charged by hand through a large door at the top of the producer, which is normally in an open position, allowing the operator unrestricted inspection of the whole upper zone of the fuel bed. The hydro-carbons con-

tained in the fuel are driven off in the upper zone, mixed with air and almost completely burned, and the burnt products, passing downward through the relatively deep bed of fuel, are decomposed and regenerated into carbon-monoxid and hydrogen gases. All of the tar and the lighter hydro-carbons are completely fixed in this process, and no tar is found in condensation in any portion of the plant after cooling. Coking or caking of the fuel bed is not detrimental, but on the other hand, assists in keeping the fire in the open porous condition, which is desirable and necessary where high rates of combustion obtain. This feature eliminates the poking necessary in the up-draft apparatus. The gas leaves the bottom of the producer through brick-lined connections, and a portion of the sensible heat is extracted in passing through an economizer. The gas is then cooled and washed and passed through an exhausting mechanism, whence it is delivered under pressure to the engine.

11 This type of apparatus lends itself admirably to the high rate of fuel combustion, which for the sake of economy in space and weight is desirable in marine service. There are in actual commercial operation today, a number of plants of this type having an average fuel consumption of over 40 lb. of good bituminous coal per sq. ft. of grate per hr. These producers are sold on a rating of from 18 lb. to 20 lb. of fuel per sq. ft. of grate per hr., which is almost 100 per cent greater than the average rating of the up-draft type of producers.

12 Undoubtedly a better method of measuring the ability or success of these two systems, is to make note of the number and capacity of plants of each type in actual operation on engine service. A report of the Committee on Gas Engines of the National Electric Light Association, spring of 1908, showed that in gas-engine power plants, of capacities of over 300 h.p. each, there were in operation 32 plants of both types having a total capacity of 57,225 h.p. Of these, 4 plants were of the up-draft type, having an aggregate capacity of 4050 h.p., and 28 plants were of the down-draft type, with an aggregate capacity of 53,175 h.p. The latter contain the Loomis-Pettibone gas-generating apparatus, some of which has been in operation on engine service for 13 years.

13 Three years have been devoted to the modification of these stationary plants for marine service. The work involved a reduction in the size and weight of the generators; complete revision of the scrubbing, gas cleansing and exhausting mechanism; elimination of all gas holders, storage receptacles, mixing chambers, etc.

14 The plant as modified to date has a light compact producer,

which while retaining the same rate of combustion as the stationary apparatus, has materially reduced dimensions and weight of the shells, brick lining, fittings, etc. The economizer boilers which were used on stationary work have been abandoned, and replaced with light air-heating economizers. The gas-coolers no longer contain any coke or broken material, or wooden trays, and are built of very light, non-corrosive sheet metal, and arranged for either vertical or horizontal positions, the latter arrangement being convenient for space which would be otherwise wasted in the vessel. The cooled and partially cleansed gas is drawn through the above portion of the plant by a centrifugal gas-cleaning exhauster, driven by direct-connected motor. The gas passes directly from the exhauster under pressure, through an automatic pressure regulating valve, to the engine manifold.

15 That the plant is adaptable for marine service with regard to space occupied and weight, may be seen from the following conservative estimate:

> Plants of from 100 to 500 h.p. each occupy from 0.4 to 0.5 sq. ft. per h.p., and weigh from 70 lb. to 90 lb. per h.p., including all auxiliaries, piping, etc.; plants of from 500 h.p. to 1000 h.p. occupy from 0.03 sq. ft. to 0.45 sq. ft. per h.p., and weigh from 40 lb. to 70 lb. per h.p., including all auxiliaries, piping, etc.

16 Undoubtedly the rational opportunity at the present time for marine gas power lies in commercial service, in which regard the most rapid advancement in America has been made in the freight, ore and fuel carriers of the Great Lakes.

17 We have therefore taken for our example a ship built from the designs of Messrs. Babcock & Penton within the last year. For the sake of clearness, the views show only the machinery space; all of the ladders, stairways and grates have been omitted from the plans, and the piping is shown only on the gas installation. The machinery installation proper is all there, however, and while the parts eliminated are merely accessory, the contrast between the two plants would be all the more striking were they included.

18 The boat is a modern Lake freighter and represents the best standard practice in this service. She is 306 ft. long over all, 45 ft. beam and 24 ft. deep. Her present power equipment consists of a single-screw, triple-expansion, three-crank condensing engine, 18–30–50 by 36 in. stroke. She indicates 1050 h.p. at 90 to 95 r.p.m. The engine is of the typical box-front columns and condenser back-frame type. She is fitted with direct-connected air pump and has independ-

ent steam-driven reciprocating, circulating, bilge, sanitary and feed pumps. The complete engine room weight, including piping and all auxiliaries, is, in round figures, 182,000 lb.

19 The boiler room equipment consists of two single-ended Scotch boilers 11 ft. 10 in. mean diameter each; 11 ft. length over heads each, operating on a working pressure of 180 lb. per sq. in. Each boiler is fitted with two 42-in. corrugated furnaces and has two hundred and forty-four $2\frac{3}{4}$-in. tubes. The grate surface is $36\frac{3}{4}$ sq. ft. and the heating surface 1642 sq. ft. in each boiler.

20 The boilers are fitted with forced draft from a 66-in. steam-driven fan. The air for the draft is taken from the stoke hole and the fan is located in the engine room. The fan discharge passes through air heaters in the up-take and thence through ducts to the under side of the grates. The complete boiler-room weight, including water in the boilers, but not fuel, is 170,000 lb. These weights are actual figures.

21 The coal bunker extends from the main deck to the tank top and is arranged athwartship. It has a capacity of 170 tons. The bunker doors face the stokers on the stoke hole floor. The bunker is 6 ft. fore and aft at the stoke hole. The distance from the forward to after bulkhead in the boiler room is 24 ft. 0 in. The distance from the forward to the after bulkhead in the engine room is 22 ft. 0 in., making a total over-all length for the plant, including bunkers, of 52 ft. 0. in.

22 The coal consumption on this vessel is from 1.08 lb. to 2 lb. per i.h.p.-hr. This coal is of approximately 13,500 B. t. u. per lb.

23 The problem of substitution of gas for steam, aside from the design of the construction of the gas producers or cylinders of the gas engines, has been thoroughly worked out by Messrs. Babcock & Penton, of Cleveland. The illustrations show two different arrangements of gas producers with the same engine. The proposed gas engine is a four-cylinder, double-acting, reversing type, having cylinders 24 in. bore by 36 in. stroke, delivering 1000 b.h.p. at 100 r.p.m. The reversing is accomplished by means of compressed air, which is used to shift the cams from the head to the stern position. Compressed air is admitted to the cylinders by timed cams in proper cycle. The crank shaft of the engine is rigidly coupled to the tail shaft of the screw.

24 The illustrations show a column-framed engine. Since making this layout, the design of the engine has been modified to meet all of the present marine conditions now found in marine engine design on the Lakes. In fact, with the exception of the condenser shown on the

steam drawings, the gas engine frame will be very similar to the steam engine.

25 For the generation of current to drive the auxiliaries, there will be installed a double-cylinder, double-acting gas engine, direct-connected to a 50-kw. direct-current generator. All of the pumps and auxiliaries will be motor-driven. A smaller direct-connected unit operating on oil will be used for pumping, blowing fires, or other service, when the gas plant is down. Allowing a distance of 4 ft. 3 in. between the forward bulkhead in engine room and the forward side of the flywheel, which distance is one foot greater than that in the steam installation, we have an over-all distance between forward and after bulkheads in the engine room of 19 ft. 6 in.

26 As previously stated, two arrangements of producer room are shown. The first, the four-generator plant, consists of four 6 ft. by 9 ft. generators, each fitted with independent economizers. The forward pair and the after pair are connected independently to two horizontal gas scrubbers, which are shown slung under the main deck beams. The gas passes from these scrubbers to independent motor-driven centrifugal gas-cleaning fans, whence it is delivered, either through common connection to a purge or blow-off pipe which also acts as a by-pass, or through two gas pressure regulator valves to the air and gas mixing valve at the engine manifold. The 6 ft. generators require only one cleaning door each. As a result a single cleaning space suffices for the four machines, allowing them to be grouped with reference to athwartship space, so as to give ample room on each side of the vessel for coal bunkers. The total space occupied by the producer plant is 21 ft. 10 in. athwartship, and 15 ft. between forward and after bulkheads. The producer room weight, including generators, economizers, piping, and scrubbers, complete, of the four-generator set, is 110,000 lb. This weight is estimated, but has been carefully checked and completely covers all the mechanism. In addition to the above mechanism, there will be a heating boiler which is shown on the main deck. This boiler will serve to furnish low-pressure steam for heating the vessel and supplying hot water for washing down decks, etc. This boiler, with water, will weigh about 8000 lb.

27 The two-generator producer plant, which will undoubtedly be the one installed, will consist of two 8 ft. diameter by 9 ft. 6 in. generators, connected to independent air economizers and each fitted with an independent horizontal scrubber, located athwartship under the main deck beams. The gas outlet at the scrubbers will be connected with a cross-over, so that either exhauster may operate either or both

producer plants. The exhausters are installed in duplicate and are connected with common purge or blow-off and common gas outlets leading either through one pressure-regulator valve, or through a by-pass direct to the air and gas mixing valves at the engine manifold.

28 On account of the fact that the 8-ft. generators require two cleaning doors set at 120 deg. the double-generator unit plant will require the full athwartship space in the producer room. The approximate floor space occupied, therefore, will be 30 ft. athwartship and 15 ft. between forward and after bulkheads. The producer-room weight, including generators, economizers, piping and scrubbers complete for the two-generator set, is 82,000 lb. This weight is estimated, but has been carefully checked and completely covers all of the mechanism. As in the case of the four-generator plant, a low-pressure boiler for heating service will be installed. In the two-generator plant, however, this boiler will be located on the producer-operating floor, so that one set of firemen may suffice for both.

29 The only guide we have for estimating the probable fuel consumption for this service is found in the large number of stationary producer gas power plants now in operation. Fortunately, in marine service, the load factor will be uniformly much higher than that found in any stationary service to which gas power is applied at the present time. The builders of this apparatus are prepared to guarantee one brake horse power per hr. on *one* lb. of good bituminous coal, averaging 13,500 B.t.u. per lb.

30 Messrs. Babcock & Penton, the engineers who designed and built the steam plant, and who have spent years on the problem of the substitution of gas for steam, have suggested that the coal bunker, which will be placed above the charging deck of the producer, should have a capacity of about 80 tons of coal. These bunkers will run from the charging deck to the deck-house and will have doors opening closely adjacent to the charging doors of the generators, so that little or no coal passing on the operating deck will be required.

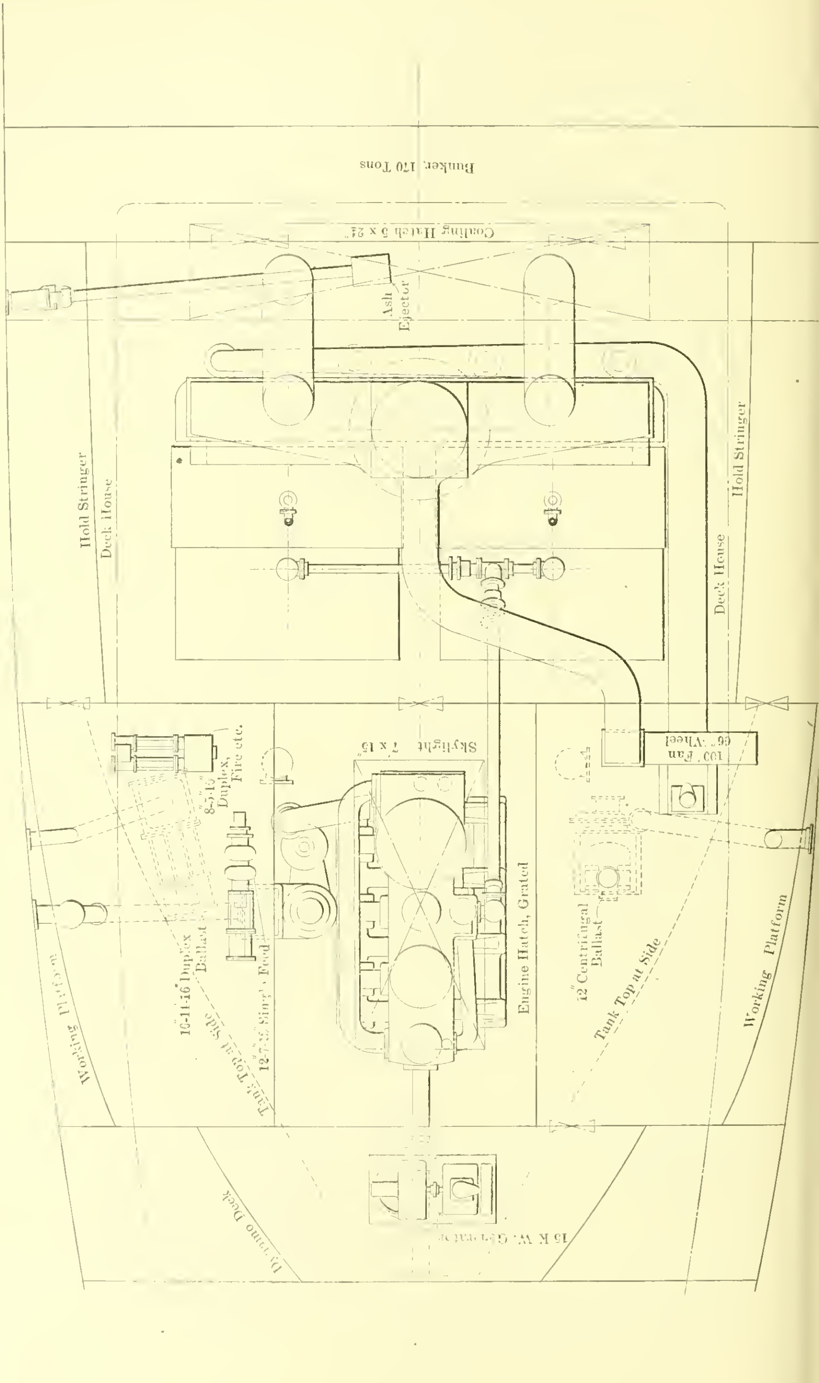
31 In making the comparison shown in the table, it is unnecessary to go into the cost of fuel, labor, hours of service, etc., as these elements vary with every class of service. In this particular proposition, it will suffice to state that the engineers who have been working on this substitution problem have conservatively figured that with the saving in fuel and the increased cargo carried, the cost of the complete plant will be saved in two years of operation.

32 While the gas plant here described has neither been constructed nor ordered at this writing, its forthcoming will not be long delayed,

TABLE I COMPARISON OF POWER PLANTS FOR GREAT LAKES FREIGHT-CARRIER

Length over all	306 ft. 0 in.	Displacement	Tons gross
Beam	45 ft. 0 in.	Cargo	4200 net lb., 18 ft. draft
Depth	24 ft. 0. in.	Speed, 12 statute miles per hr. on 900 i.h.p.	

Steam	Gas
ENGINE ROOM	ENGINE ROOM
3-cylinder triple-expansion, condensing, 18–30–50 by 36 in., 1050 i.h.p. at 90 to 95 r.p.m.	4-cylinder, 4-cycle, double-acting, gas engine, 24 in. diam., by 36 in. stroke 1000 b.h.p. at 95 r.p.m.
Auxiliaries steam-driven	Auxiliaries motor-driven
Length between bulkheads, 22 ft. 0 in.	Length between bulkheads, 19 ft. 6 in.
Engine room weights, including auxiliaries and piping, 182,000 lb.	Engine room weights, 105,000 lb.
BOILER ROOM	PRODUCER ROOM
2 single-ended Scotch boilers fitted with economizers, forced draught. Length each boiler, overheads 11 ft. 0 in.	Two down-draft gas producers and auxiliaries
Mean diameter, each, 11 ft. 10 in.	Diameter shell, each generator, 8 ft. 0. in.
Two 42-in. furnaces each	Inside diameter, lining generator, 6. ft. 3 in.
244 2¾-in. tubes, each	
	Height shell, each generator, 9 ft. 6 in.
Grate surface, each, 36.75 sq. ft.	Grate surface, each generator, 30.67 sq. ft.
Heating surface, each, 1642 sq. ft.	
Boiler room weight, water in boilers, no fuel, 170,000 lb.	Producer room weights, no water, no fuel, 82,000 lb.
Length boiler room 24 ft. 0 in.	
Length boiler room, includes bunkers, 30 ft. 0 in.	Length producer room, includes bunkers, 15 ft. 0 in.
	Square feet producer room, 450
	Square feet per h.p., 0.45
Square feet boiler room, including bunkers, 900	Square feet producer room with four smaller generators, 330
Square feet per h.p., 0.9	Square feet per h.p., four generators, 0.33
Bunker capacity, 340,000 lb.	Bunker capacity, 160,000 lb.
Total weight, machinery and fuel, 692,000 lb.	Total weight, machinery and fuel, 347,000 lb.
Total length of machinery space including bunkers, 52 ft. 0 in.	Total length of machinery space, 34 ft. 6 in.
	Saving in weight, 355,000 lb.
	Saving in fore-and-aft length, 17 ft. 6 in.
	Saving in cubic space 17 ft. 6 in. by 32 ft. beam by 20 ft. high, 11,200 cu.ft.


Bunker, 170 Tons
Coaling Hatch 5 x 24'
Ash Ejector
Hold Stringer
Deck House
Deck House
Hold Stringer
Skylight 7' x 15'
100" Fan
66" Wheel
8-5-15 Duplex, Fire etc.
16-11-16 Duplex Ballast
12-7-18 Single Feed
Tank Top at Side
Working Platform
Engine Hatch, Grated
12" Centrifugal Ballast
Tank Top at Side
Working Platform
Dynamo Deck
15 K.W. Generator

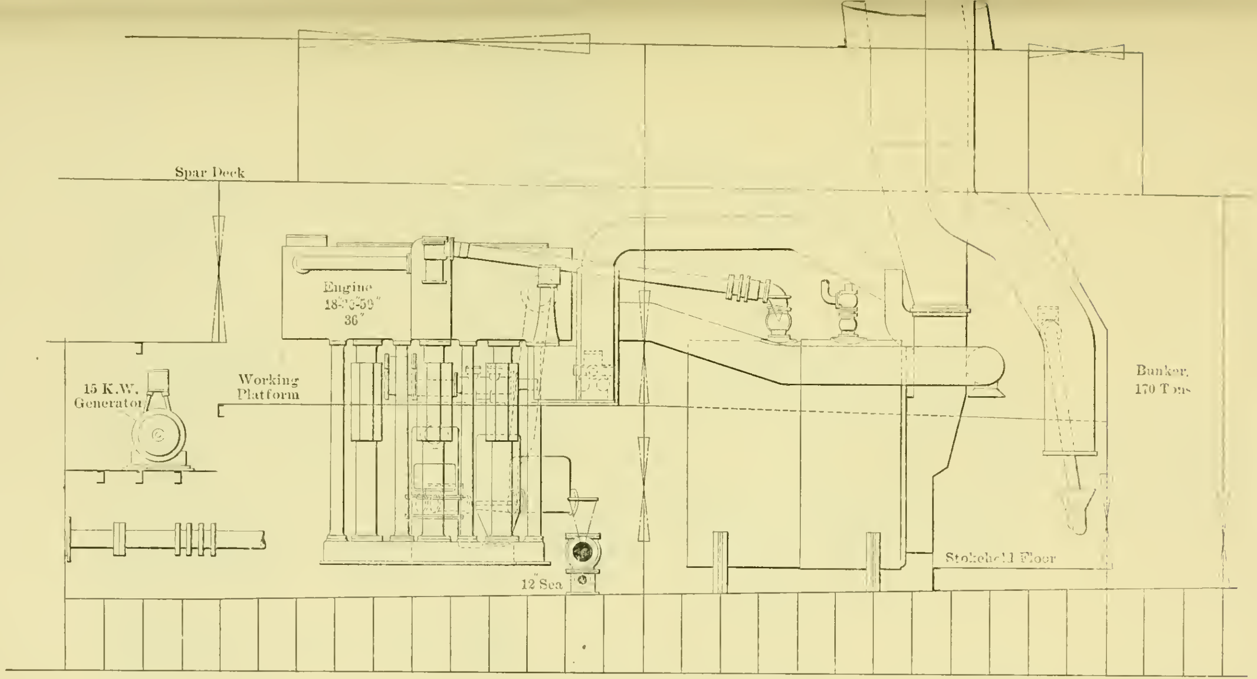
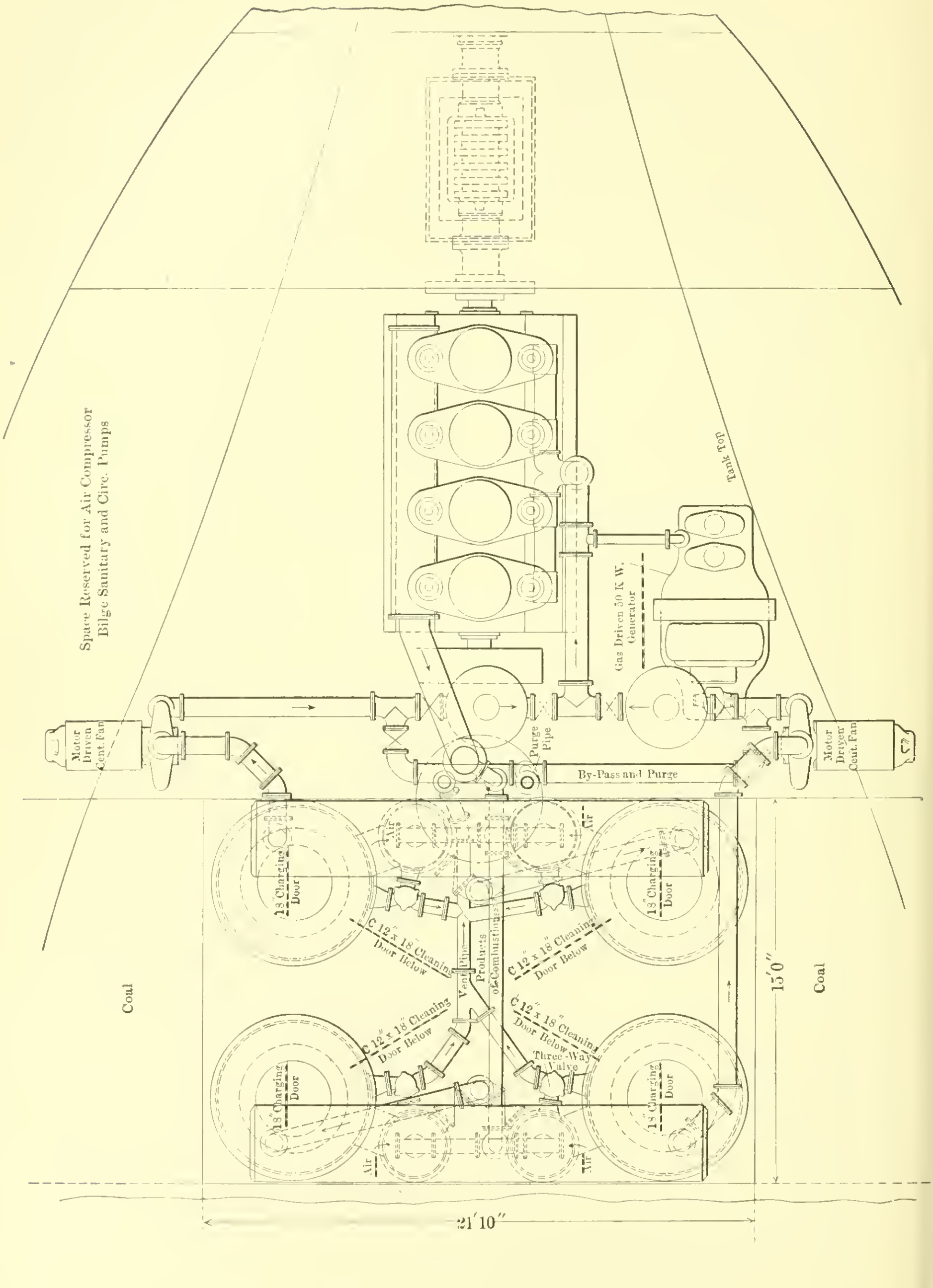


FIG. 1 PLAN AND ELEVATION OF 1000 H. P. STEAM POWER EQUIPMENT NOW INSTALLED IN LAKE FREIGHTER. TRIPLE-EXPANSION ENGINES; TWO SCOTCH BOILERS


Space Reserved for Air Compressor
Bilge Sanitary and Circ. Pumps
Tank Top
Gas Driven 50 K.W. Generator
Motor Driven Cent. Fan
Motor Driven Cent. Fan
Purge Pipe
By-Pass and Purge
Air
Air
Air
Air
18" Charging Door
18" Charging Door
18" Charging Door
18" Charging Door
℄ 12" x 18" Cleaning Door Below
℄ 12" x 18" Cleaning Door Below
℄ 12" x 18" Cleaning Door Below
℄ 12" x 18" Cleaning Door Below
Vent Pipe
Products of Combustion
Three-Way Valve
Coal
Coal
15'0"
21'10"

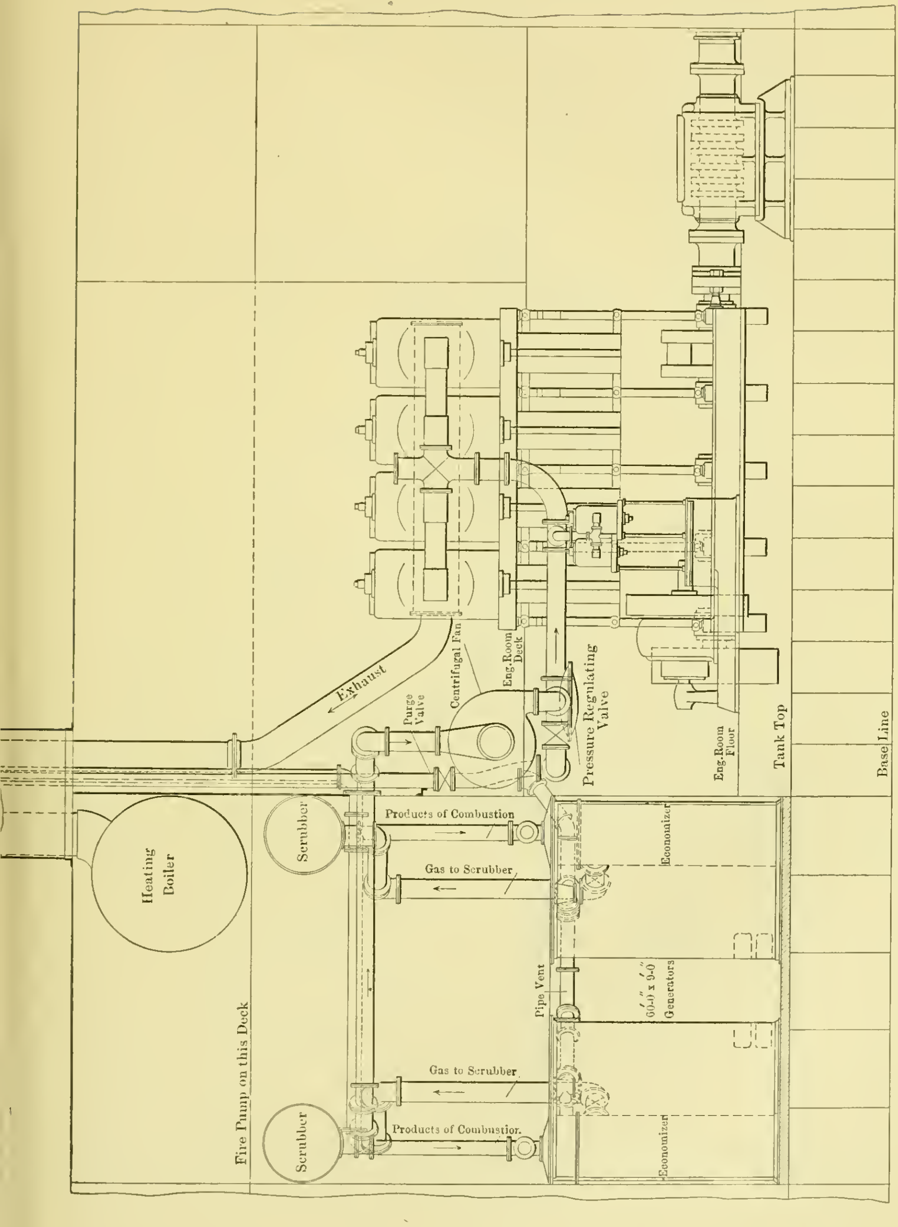
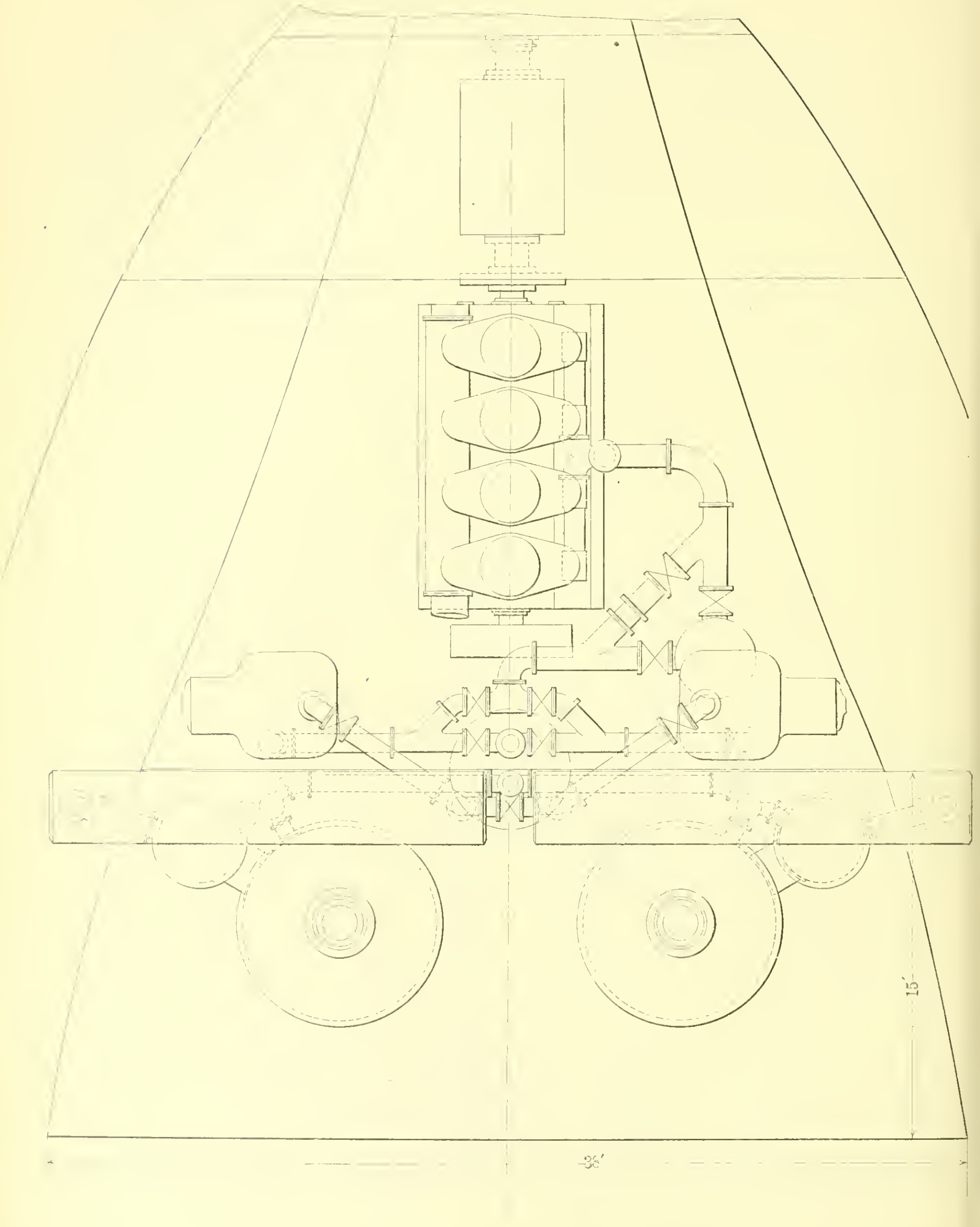


Fig. 2 Plan and Elevation of Proposed Four-Generator Marine Producer Plant; 1000 h.p.


15'
36'

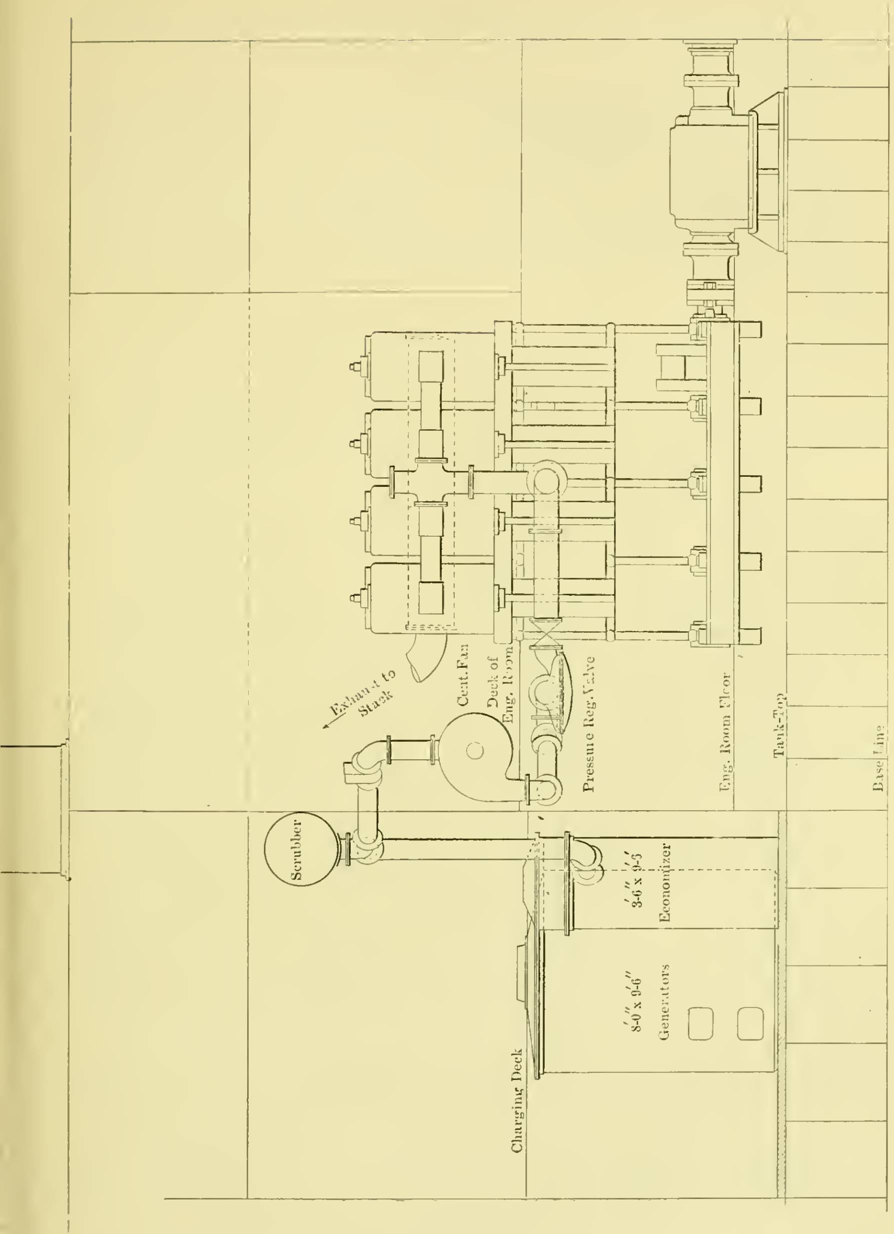


FIG. 3 PLAN AND ELEVATION OF PROPOSED TWO-GENERATOR MARINE PRODUCER PLANT; 1000 H.P.

and this comparison, while somewhat premature, is made to present the possibilities of marine producer gas power to those interested in its future.

33 A marine bituminous gas plant, similar in construction and operation to the one described, but of 300-h.p. capacity, has been in commercial operation driving a six-cylinder, single-acting, reversing marine gas engine for over a year. The results obtained give ample security for the statements made in this paper, and point to the early adoption of this type of prime mover for our marine commercial service.

A UNIQUE BELT CONVEYOR

By E. C. Soper, Detroit, Mich.
Member of the Society

It is quite possible that a description of a belt conveyor a quarter of a mile long, and requiring more power to operate empty than loaded, will be interesting to some of the members and since its installation and operation are at variance from the prescribed rules of conveyor design, we beg to submit the following:

2 The belt conveyor was built during the summer of 1908 in one of the large portland cement plants of the South. It consists of a 24-in. 8-ply canvas belt in two sections, one section about 1000 ft. between centers, and the other with 1100 ft. between centers, its function being to convey the shale used in the manufacture of the cement, from the shale quarry to the plant. The shale deposit is located on a mountain about 247 ft. above the shale storage tanks, as shown in profile, Fig. 1. The two sections intersect at an angle of 140 deg. 40 min., so that the blasting from the limestone quarry does not interfere with the operation of the belt. The belt conveys the shale around the limestone quarry, as shown in plan, Fig. 1.

3 The belt is flat and carried by rollers, the top row having 4 ft. between centers and the return idlers 12 ft. between centers. Guide rollers are placed with about 40 ft. between centers along both upper and lower belts. (See Fig. 2.) The majority of manufacturers of belt conveyors recommend the maximum length between centers of a single belt to be about 700 ft. to 800 ft.

4 Referring to Fig. 1, the belt conveys the material down-hill, and to this fact is due the apparently parodoxical results in power required to operate, shown in Tables 1 and 2.

5 Because of the extreme length of the belt, and the fact that there is no roof or other covering, it was necessary to install some system for taking care of the expansion and contraction, in addition

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To be presented at the Washington Meeting (May 1909) of The American Society of Mechanical Engineers. All papers are subject to revision.

to the ordinary stretch of the belt, which is taken up in the majority of installations by 24-in., 36-in. or 48-in. takeups, according to length of belt. A set of 36-in. takeups, (Fig. 3) was installed at the upper end of each of these belts to maintain alignment and equal tension on each edge of the belt. The system installed acts as a tension carriage and makes it less often necessary to cut out the slack in the belt, and in cool and wet weather the belt adjusts itself, the increased tension due to contraction raising the weight in the tower. A 10-h.p. motor drives each section. The lower section has a 6-ft. drop and requires approximately 5.1 h.p. to operate empty and 5.1 h.p.

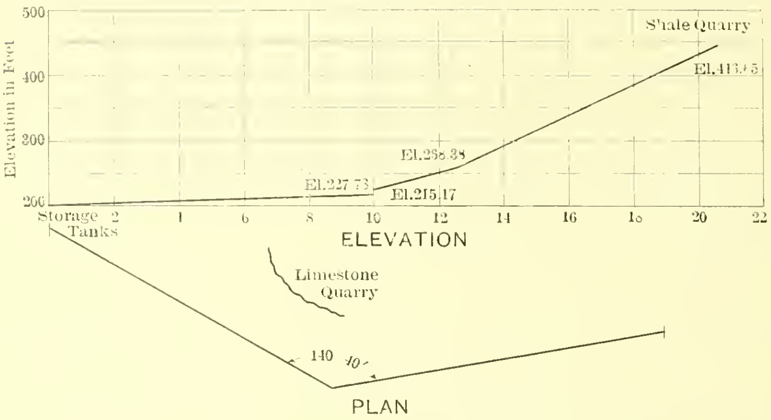

Fig. 1 Profile Showing Elevation and Plan of Conveyors

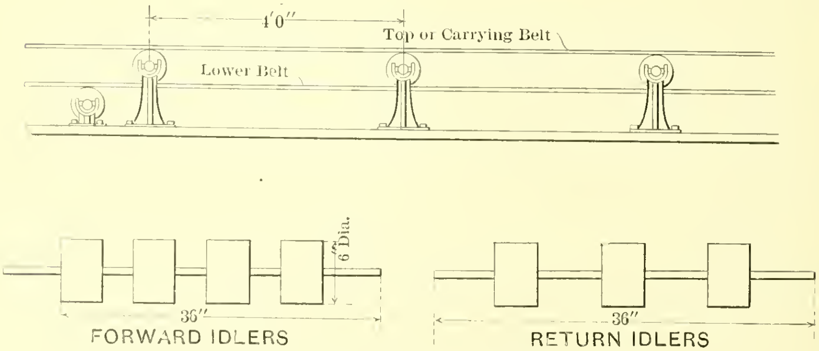

Fig. 2 Details of Forward and Return Idlers

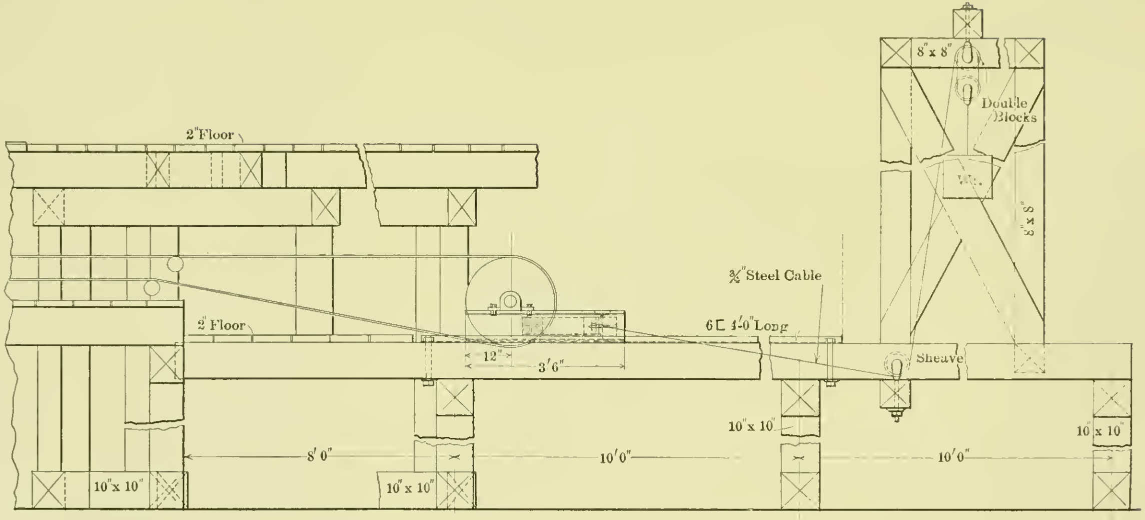

Fig. 3. Details of Take-up Arrangement for Belts

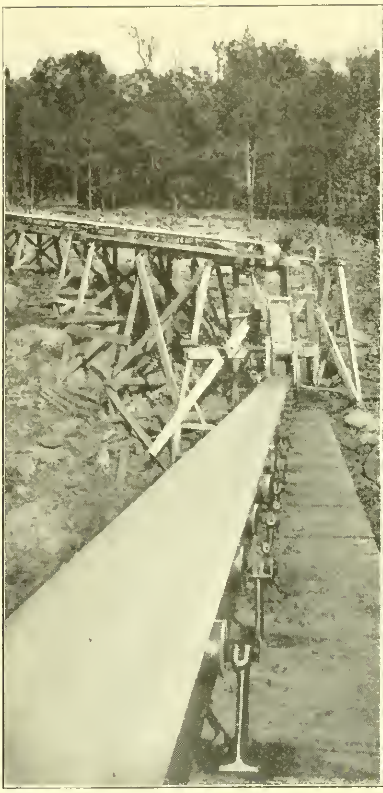

Fig. 4 View of Discharge from Upper to Lower Section

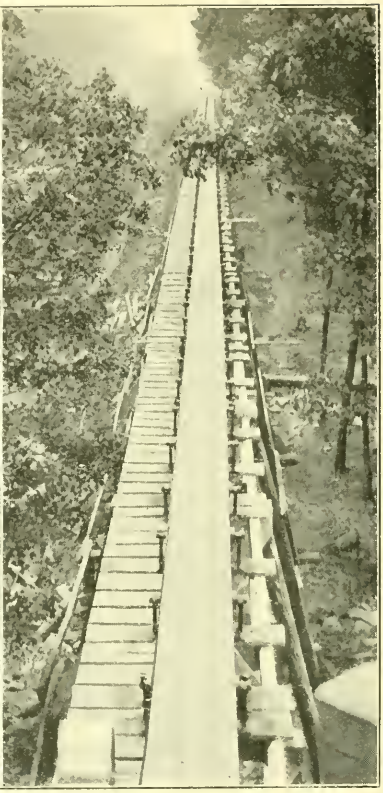

Fig. 5 Looking Down on First or Lower Section

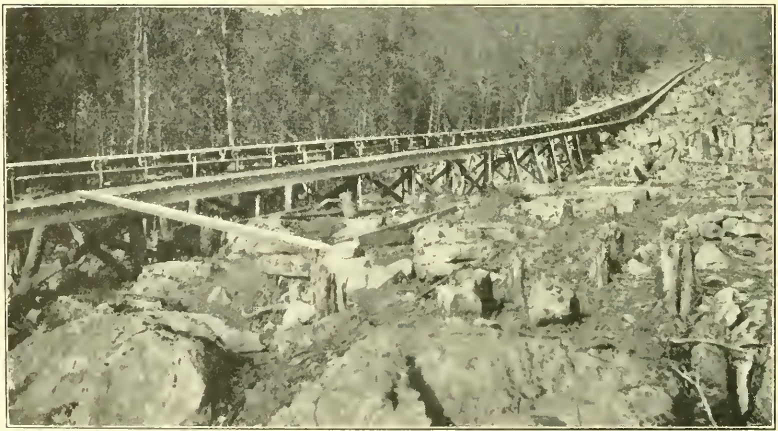

Fig. 6 Side View of Upper Section

to carry a load of 1200 lb., as shoveled by ten men. (See tests which follow.) The discharge from the upper to the lower sections through a chute is shown in Fig. 4. There is no spilling of material at any point of the travel, and pieces of shale a cubic foot in size are carried. The upper section is driven, contrary to practice, at the upper end, the pull being on the lower or slack side of the belt, but in this case, due to the pull of gravity on the top side, the belt was found to work better with the pull on the lower side.

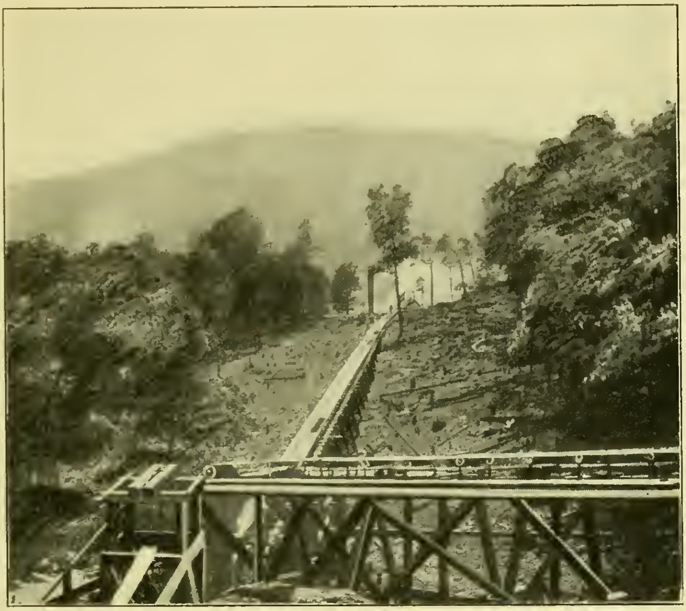

Fig. 7 General View Showing Both Belts

6 The several halftones give views of the belt taken from different points. In clearing a way through the woods, the poles obtained were utilized for trestling and the planking was obtained from the scrap pile of concrete-form lumber.

7 Fig. 6 is a side view of the lower end of the upper section, showing the two depressions in the belt, and though these depressions do not conform closely to the prescribed radius of 300 ft., there is no lifting of the belt from the carrying idlers.

8 Power tests were made on the two sections after the belt had been operating a few days, with the following results: the speed of

the belt of the lower section, which has a grade of 2.4 per cent for 665 ft., or 0.024 × 665 = 16 ft., was 146 ft. per min.; the belt was driven by a 10-h.p. direct-current Westinghouse motor, and was loaded 2.2 lb. per ft. for a distance of 550 ft., or 1210 lb.; this load fell 16 ft. in 5 min. Then

$$\frac{1210 \times 16}{5} = 3520 \text{ ft.-lb. of work exerted by load}$$

or,

$$\frac{3520}{33{,}000} = \frac{1}{11} \text{ h.p. (approx.) helping to pull the belt.}$$

When the belt was loaded as above, a test of the motor showed that 16 amperes, 239 volts, or 5.1 h.p., were required. There was no appreciable difference in the ammeter and voltmeter readings, when belt was empty or loaded, as in test.

9 When the belts were installed, after trying them out and ascertaining how easily they could be operated, a sprocket was placed on the tail-shaft of the lower section and also one on the head-shaft of the upper section, and the two sprockets were connected by a vertical quarter-twist chain. The idea was to drive both belts by a 10-h.p. motor at the head of the lower belt section, after all shafts had become well seated in the bearings and the stiffness had disappeared from the belt and it was in good operating condition. This was also necessary in order to take up the slack in the upper section when starting, and *the speeds were such that the top side of the belt ran 3 ft. per min. faster than the lower side.* The results of a series of tests are given in Tables 1 and 2.

TABLE 1 POWER TESTS OF BELTS UNDER CONDITIONS NOTED IN TEXT

Time (a.m.)	Volts	Amperes	Watts	h.p.	Notes
9:50	207	12	2484	3.3	Belts chained together Eight men loading
10:08	210	12	2520	3.3	
10:09	208	14	2912	3.9	Connecting chain off, 10-h.p. motor only
10:11	210	14	2940	3.9	
10:15	200	14	2800	3.7	Gradual increase in electrical load due to decrease in shale load
10:20	200	15	3000	4.0	
10:35	200	16	3200	4.2	

Note: Low voltage due to very small mains and long distance (2500 ft.).

TABLE 2 SECOND SERIES OF TESTS

Time (p.m.)	Volts	Amperes	Watts	h.p.	Notes
2:00	194	16	3104	4.1	Empty. Connected to lower belt by chain
2:15	180	16	2886	3.8	All readings at motor and not including line loss
2:25	182	18	3275	4.4	
2:35	186	18	3348	4.4	
3:45	195	14	2730	3.6	Loaded by seven men
3:50	185	19	3515	4.7	Loaded as before, but with connecting chain off. 10-h.p. motor only

Note: Readings taken on motor at upper end of upper belt-section.

Initial and Operating Costs

10 Tables are given herewith upon the first cost of the equipment (Table 3) and the cost of operation and maintenance (Table 4). Table 4 is based upon a capacity of 200 tons conveyed in ten hours. Inasmuch as the capacity is directly proportional to the speed, if it was desired to increase the capacity of the conveyor, it would only be necessary to increase the travel of the belt per minute, and from experience, it is quite possible that by doubling the load the power required to operate would be reduced 50 per cent.

11 The operation costs given in Table 4 are taken from actual practice. Doubling the capacity per day and assuming above costs to be approximately the same reduces the actual cost of conveying to $0.0038 per ton. Interest and depreciation, $0.0063, or a total of $0.0101.

TABLE 3 COST PER FOOT OF COMPLETED BELTS INCLUDING ELECTRICAL MOTORS, TRESTLING, ETC.

Materials	Total Cost	Cost per Ft.
Lumber	$ 496.34	$0.238
Belt	5361.52	2.58
Castings	1435.77	0.69
Electrical equipment, including two 10-h.p. motors	637.11	0.316
Miscellaneous: nails, bolts, screws, iron, etc	193.20	0.093
Labor	962.20	0.46
	$9106.16	$4.37

Note: Length of first section, center to center, 998 ft.; second section, 1082 ft.; total, 2080 ft.; takeup, 15 ft.

Cost of castings includes machine work, etc.

12 Regarding the operation of the belt: after the stiffness had disappeared there was very little slipping at the head or drive pulleys, and there was sufficient lubrication in the shale itself to form a waterproof covering about $\frac{1}{8}$-in. thick on the belt, thereby protecting it not only from wear but from the action of the elements, and proving a very good dressing to keep the belt pliable. Because of the slow speed, etc., there are very few repairs necessary to the belt, and in this instance, being coated as described above, the belt should last several years.

TABLE 4 COST TO OPERATE AND MAINTAIN BELT CONVEYOR

		PER 10 HR. DAY	PER TON
POWER			
10 h.p. at $0.004 per h.p.-hr.		$0.40	$0.002
LABOR			
Boy oiling, etc.	$0.75		
Taking up slack once in 7 days, 2 men, 3 hr. at $0.20 per hr	0.171	0.92	0.0046
SUPPLIES			
Belt Lacing	0.10		
Waste, Resin, etc.	0.10	0.20	0.001
Total		$1.52	$0.0076
Oil (no charge, using waste oil from large crushers).			
INTEREST, ETC.			
Interest, Depreciation, Renewals, 10 per cent on investment of $9200		2.52	0.0126
Grand Total		$4.04	$0.0202

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BOOKS

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CONCRETE, ITS USES IN BUILDING FROM FOUNDATION TO FINISH. 3d edition. By Thomas Potter. *London, B. T. Batsford, 1908.* Purchase. $3.

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CYCLOPEDIA OF THE BUILDING TRADES. By F. T. Hodgson. 6 vol. *Chicago, American Building Trades School, 1907.* Purchase. $12.

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ELECTRICAL SYSTEM OF THE LONDON COUNCIL TRAMWAYS. Institution of Electrical Engineers. By John Hall Rider. Gift of C. W. Rice.

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FACTORY MANAGER AND ACCOUNTANT. By H. L. Arnold. *New York-London, Engineering Magazine, 1905.* Purchase. $5.

FUNCTION OF CHEMISTRY IN THE CONSERVATION OF OUR NATURAL RESOURCES. By M. T. Bogert. Reprinted from the Journal of the American Chemical Society, vol. 31, no. 2, *February 1909.* Gift of M. T. Bogert.

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GAS TURBINE ENGINE, A. W. H. Griepe, inventor. Specification of Letters Patent, no. 910,665. January 26, 1909. *U. S. Patent Office.* Gift of A. W. H. Griepe.

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HYDRAULICS AND ITS APPLICATIONS. By A. H. Gibson. *New York, Van Nostrand Co., 1908.* Purchase. $5.

ILLUSTRATED TECHNICAL DICTIONARY IN SIX LANGUAGES. Vol. 4. By Alfred Schlomann. *New York, McGraw Publishing Co., 1908.* Purchase. $3.

IOWA RAILWAY CLUB. *Proceedings.* Vol. 9, no. 2-date. *Des Moines, 1909.* Gift.

LATHE DESIGN FOR HIGH AND LOW SPEED STEELS. By J. T. Nicolson and Dempster Smith. *London, Longmans, Green & Co., 1908.* Purchase. $6.

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LEATHER MANUFACTURE. 5th edition. By Alexander Watt. *New York, Van Nostrand Co., 1906.* Purchase. $4.

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MANUAL OF REINFORCED CONCRETE AND CONCRETE BLOCK CONSTRUCTION. By C. F. Marsh and Wm. Dunn. *New York, Van Nostrand Co., 1908.* Purchase. $2.50.

MECHANICAL ENGINEERING OF STEAM POWER PLANTS. 3d edition, rewritten. By F. R. Hutton. *New York, J. Wiley & Sons, 1908.* Gift of publishers.

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MOTOR VEHICLES FOR BUSINESS PURPOSES. By A. J. W. Taylor. *London, Crosby Lockwood & Son, 1905.* Purchase. $3.50.

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POOR'S MANUAL OF RAILROADS OF THE UNITED STATES, 1908. *New York, 1908.* Purchase. $10.

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PROCEEDINGS OF "UNIVERSITY DAY," FEBRUARY 22, 1909, OF THE UNIVERSITY OF PENNSYLVANIA. *Philadelphia, 1909.* Gift.

PROFIT MAKING IN SHOP AND FACTORY MANAGEMENT. By C. U. Carpenter. *New York, Engineering Magazine, 1908.* Purchase. $2.

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STEAM TURBINE ENGINEERING. By T. Stevens and H. M. Hobart. *New York, Macmillan Co., 1906.* Purchase. $6.50.

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TIMBER. By J. R. Baterden. *New York, Van Nostrand Co., 1908.* Purchase. $2.

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WATER POWER ENGINEERING. By D. W. Mead. *New York, McGraw Publishing Co , 1908.* Gift of publishers.

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GIFT OF ISAAC C. GREEN

ALLEGEMEINE MASCHINENLEHRE. By Dr. Moritz Rühlmann. 2d edition. 4 vol. *Braunschweig, C. A. Schwetschke & Sohn, 1875.*

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Steam Ship Capability, Power, Consumption of Fuel, Cargo Capacity. By Thomas Wingate. 1st edition. *Glasgow, A. & W. MacTear.*

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Vorträge über Geschichte der theoritischen Maschinenlehre und der damit in Zusammenhang stehenden mathematischen Wissenschaften. By Dr. Moritz Rühlmann. 1st edition. 3 vol. *Braunschweig, C. A. Schwetschke & Sohn, 1881.*

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SIGNIFICANCE OF DRAFTS IN STEAM BOILER PRACTICE. (U. S. Geological Survey, Bulletin no. 367.) By W. T. Ray and Henry Kreisinger. *Washington, Government, 1909.*

CATALOGUES

ALBERGER PUMP COMPANY, *95 Liberty Street, New York, September 1908.* Catalogue B. Volute Centrifugal Pumps.

AMERICAN BLOWER COMPANY, *Detroit, Mich.* Shop Heating. A Treatise Containing Practical Suggestions. By F. R. Still. *1908.*

AMERICAN BRASS MANUFACTURERS. Price List no. 7.

CONTINENTAL IRON WORKS, *Brooklyn, N. Y.*

Catalogue for 1908. 7th edition. Photographs and descriptions of internal furnace tubular boilers with Morrison suspension furnaces of all styles; tables showing rating of power of boilers; sectional drawings and designs of boilers ranging from 50 h.p. to 300 h.p.; testimonials as to efficiency of boilers where used.

DU BOIS IRON WORKS, *Du Bois, Pa.* Motor, Gasoline Engine and Belt Driven Pumps. Bulletin EP, no. 3.

FAIRBANKS, MORSE & CO., *Chicago, Ill.* Bulletin no. 21, Standard "TR" Type D. C. Dynamos and Motors; Bulletin no. 23, Standard "E" D. C. Dynamos and Motors; Bulletin no. 26, Fairbanks, Morse Special Motors; Supplement, Back Geared Motors; Bulletin no. 32, Direct Connected Exhaust Fans; Bulletin no. 38, Engine Type Generators; Bulletin no. 204, A. C. "B" Type Induction Motors; Bulletin no. 205, A. C. "B" Type Generators; Bulletin no. 206, A. C. Engine Type Generators; Bulletin no. 207, A. C. Induction Motors, Types BH and BV. Catalogues, no. 44D, Horizontal Engines; no. 45C, Hoists; no. 47C, Pumping Machinery; no. 48D, Steam Pumps.

HOOVEN, OWENS, RENTSCHLER COMPANY, *Hamilton, Ohio.* Type H. S. High Speed Corliss. Bulletin no. 104.

JEFFREY MANUFACTURING CO., *Columbus, O.* Catalogue no. 32A.

Coal and ashes handling machinery for power plants, and places where machinery has been successfully used.

CHAS. C. MOORE & COMPANY, *San Francisco, Cal.* A Modern Steam Power. Central Station.

NATIONAL MACHINERY COMPANY, Tiffin, Ohio. Catalogue E.

Bolt, nut and rivet machinery, upsetting and forging machines, and wire nail machines. Tables showing dimensions of manufacturers' standard bolts, heads, nuts.

NELSON VALVE COMPANY, *Wyndmoor, Philadelphia, Pa.* Catalogue. *1909.*

NILES-BEMENT-POND COMPANY, *New York.* Bement Hammers.

Northwestern Expanded Metal Company, *930 Old Colony Bldg., Chicago, Ill.* Expanded Metal Information, Concrete and Steel. *1908.*

Pratt and Whitney Company, *Hartford, Conn.* Gages and Standards.

Randolph-Clowes Company, *Waterbury, Conn.*

Seamless drawn brass and copper tubing, tanks and shells, brazed tubes, moldings, sheet brass and brass rods, Brown & Bros. seamless drawn copper range boilers.

Scully Steel & Iron Co., *Halstead and Fulton Sts., Chicago, Ill., March 1909.* Stock list of steel and iron goods with dimensions and stock prices.

Termaat & Monahan Co., *Oshkosh, Wis.*

Catalogue, showing detail construction and explanation of two, three, and four-cylinder reversible, T. & M. marine engines.

Hubert H. Ward and Associates, *Cleveland, O.*

Seaton spring wheel, suitable for automobiles, trucks, and railway cars; full description of principle, construction and advantages.

Ward Leonard Electric Co., Bronxville, N. Y.

Motor Starters, equipped with tightcasings enclosing all current-carrying parts, for automatically starting motor, and accelerating to full speed, or restoring rheostat lever to starting position in case of interruption of current supply,

Westinghouse Electric and Manufacturing Company, *Pittsburg, Pa.* Luminous Radiators and Air Heaters, Folder 4120, *Feb. 1909.* Direct Current Electric Fans, Folders 4100, 4101, *Jan.* 1909. Battery Charging Methods, Folder 4134, *March 1909.* Electric Sad Iron, Folder 4098, *Feb. 1909.* Multiple Tungsten Lamps for Alternating or Direct Current Circuits, Circular no. 1160.

COMMENT ON CURRENT BOOKS

The Steam Turbine. A Practical and Theoretical Treatise for Engineers and Designers, including a discussion of the gas turbine. By James Ambrose Moyer, S.B., A.M., *John Wiley & Sons. New York.* 1908. Cloth, 8vo. ix + 370 p., 225 figures. Price, $4 net.

Professor Moyer has had an extended experience in experimental work incident to the manufacture of steam turbines, and also as an instructor in engineering. He has aimed in this treatise to explain some of the more important problems connected with steam turbines. Two chapters of unusual interest to the designing engineer are upon nozzle design and blade design. Nozzles are becoming an important element in all types of turbines and many conditions affecting their efficiency are now well established. Illustrative examples are worked out in these two chapters and to supplement the calculations upon blade design in which allowance must be made for mechanical losses, a discussion of these losses is given, with an estimate of their probable magnitude. The chapter upon turbine tests is meager, but with it must be considered two other chapters, one upon turbine economy, and one upon methods for correcting turbine tests. Under turbine economics are discussed the influence upon economy of steam pressure vacuum, superheated steam, etc., together with operative and initial costs, plant design and operation, etc. A chapter relates to corrections that must be made to compensate for different conditions under which tests are made, with a view to bringing results to a standard basis for comparison. There is a chapter on stresses in rotating rings, drums and disks, a brief discussion on gas turbines, and by way of introduction a very clear treatment of the elementary theory of heat, with special reference to the temperature-entropy diagram as applied to turbine operations. There is a comprehensive description of commercial types, including low-pressure turbines. The marine turbine receives but a brief treatment in a very short chapter.

Contents by chapter headings: Introduction; The elementary Theory of Heat; Nozzle Design; Steam Turbine Types and Blade Design; Mechanical Losses in Turbines; Method for Correcting Steam Turbine Tests; Commercial types of Turbines, De Laval, Parsons, Westinghouse, Allis-Chalmers, Curtis, Rateau, Wilkinson, Zoelly, Sturtevant, Riedler-Stumpf, Kerr, Terry, Dake, etc.; Governing Steam Turbines; Low Pressure (exhaust) Turbines; Marine Turbines; Steam Turbine Economics; Stresses in Rings, Drums, and Disks, Design of Turbine Wheels, Critical Speeds of Loaded Shafts; Gas Turbines; Electric Generators for Turbines, Direct-Current Generators, Alternating-Current Generators.

A Pocket Book of Mechanical Engineering. Tables. Data, Formulae, Theory and Examples. For Engineers and Sudents. By Charles M. Sames, B.Sc. *Jersey City, N. J.* 1908. Third edition, revised and enlarged. Pocket size, leather, vii + 195 p. Price $2.

A pocket-book in reality as well as in name is this little reference work of mechanical engineering, now in its third edition. The table of contents shows its scope.

The effort has been to cull out from engineering data the formulae, tabular matter and other information usually required by mechanical engineers and students, and having for an aim the presentation of the material in an exceedingly condensed form without duplication of data, with a view to making the book compact. In the third edition new matter has been added upon reinforced concrete, high-speed tool steel, superheated steam and journal friction. It is printed in small type on thin paper, with flexible leather covers, after the usual style of the better class of pocket-books.

Contents, by chapter headings: Mathematics, Chemical Data; Materials; The Strength of Materials, Structures, and Machine Parts; Energy and the Transmission of Power; Heat and the Steam Engine; Hydraulics and Hydraulic Machinery; Shop Data; Electrotechnics; Appendix.

ACCURATE TOOL WORK. By C. L. Goodrich and F. S. Stanley. *Hill Publishing Company, New York.* 1908. Cloth, 6 by 9, 217 p., 221 illustrations. Price, $2 net.

The development of accurate processes in the manufacture of tools and machine parts has extended to nearly every branch of machine manufacture and refinements in methods are to be found in almost all tool rooms. Many of these methods originated in watch factories and similar establishments, but they have been found applicable in producing work of different character and heavier proportions. This book treats of these methods, dealing with the use of master plate, disc, button and test indicator processes, the use of the microscope in connection with micrometer measurements and other ingenious processes, and methods of measuring tapers and angular work. Mr. Goodrich, department foreman with the Pratt & Whitney Co., Hartford, Conn., has had long experience in work of this kind, and Mr. Stanley, associate editor of the American Machinist, is a practical tool maker. Much of the material has been contributed by the authors or by others to the columns of the American Machinist. The book is handsomely illustrated, both by diagrams and half-tone engravings from photographs of actual work. It places on record in convenient form much needed information upon modern shop methods of accomplishing the most accurate results possible in machine work.

Contents by chapter headings: Locating and Boring Holes in Drill Jigs; Locating and Boring Oblique Holes in Jigs; Economical Jig Work on the Milling Machine; Boring Holes on the Miller and Checking with Verniers: A Precision Drilling and Reaming Machine; Master Plates and How They are Made; Master Plates and Their Uses in Die Making; Master Plates Used in Making Watch Tools; Trigonometry in the Tool Room; A Tool for Laying Out Angles; Measuring Dovetail Slides, Gibs and V's; A Gage for Producing Accurate Tapers; The Microscope in the Tool Room; The Microscope in the Manufacturing Plant; Making a Set of Accurate Index Dials; Inspecting Tools with the Test Indicator; A Universal Indicator and Some of Its Applications; A New Swedish Combination Gaging System; Setting, Laying Out and Testing Work with the Swedish Gages.

THE ECONOMY FACTOR IN STEAM-POWER PLANTS. By George W. Hawkins. *Hill Publishing Company, New York.* 1908. Cloth, 6 by 9. 133 p., 50 figures. Price $3 net.

The author has presented a discussion with ample data upon the economical design and operation of steam power plants. It is only consideration of the economy of each of the elements of a plant that leads to a high plant efficiency, and the author, therefore, properly introduces the subject by a chapter on individual apparatus. In this are considered the economy of several leading types of engines and of turbines, with a review of controlling factors in condensing apparatus, feed water heaters, economizers, etc. Diagrams have been plotted giving the steam economy of engines of different types and sizes when operating under different loads. Data are given upon steam or power required for circulating pumps, air pumps, feed pumps, etc. A comprehensive chapter treats of plant economy as a whole, with many diagrams and tables and calculations carried through for different arrangements of apparatus and plans of operation. These relate to non-condensing, surface condensing and jet condensing plants, with auxiliaries direct-connected and belted; and with auxiliaries steam-driven and motor-driven. Conclusions derived by the author's methods will prove illuminating and valuable to those who have to predetermine the results from various types of power plants under certain conditions; he discusses variable loads which have so important a bearing on the economy of practically all power plants. There are also diagrams and tables for reducing the performance of a boiler to the standard basis of "from and at 212 deg." taking into account the feed water temperature and steam pressure. The author has based his book upon the use of fuel oil and has supplied conversion charts to afford ready means of converting the heat elements of oil to those of coal or wood.

Contents by chapter headings: Introduction. Part I. Individual Apparatus; Boilers; Engines; Electrical Generators; Condensing Apparatus; Feed-Pumps; Oil-Pumps; Oil-Burners, Radiation, Leakage; Feed-Water Heaters; Fuel Economizers. Part II. The Factor of Evaporation. Part III. Complete Plant Economy: Introductory; Non-Condensing Plants; Surface-Condensing Plants; Jet-Condensing Plants; Pumping Plants; Examples. Part IV. Complete Plant Economy: Phases of the Problem; Method of Solution. Conclusion.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

058 Construction work—reinforced concrete bungalows and cottages—organization in need of an engineer having had varied experience in reinforced concrete, experienced in calculating strains and stresses and proportioning members for load and weight; plan is by pilaster or palisade with thin curtain walls. Location Pennsylvania.

059 Man of wide experience in manufacture of automobiles, as general foreman. Location Rhode Island.

060 Well-equipped machine shop with equipment to run about twenty-five men; present owner wishes to devote time to certain patents and desires someone to take charge of present shop; will finance the proposition if necessary or form small stock company giving the proper party full charge. Location Maryland.

061 Shop superintendent, energetic, good systematizer with thorough experience in building steam engines and medium explosion engines, also pumps or compressors, if possible. Must be competent to determine the most economical methods of machining any given piece and be familiar with the whole of modern shop practice.

062 Wanted: prominent engineer of wide experience as specialist in ice-making machinery.

063 Manager of an iron works employing 50 to 75 men, doing general foundry and machine work as is usual in connection with mining, smelting and concentrating machinery. Man of good business ability and training as well as having general engineering experience essential. Location Montana.

064 Superintendent of one of the largest machine-tool concerns in the United States wants young man who can grow up in the establishment, and finally take superintendent's position. Preferably not over thirty years old. Must have had a varied and practical experience on engineering matters outside of the ma-

chine-tool lines. Must speak English and some German. Should have University education, executive ability, and good address. If you are the man I am looking for, write Superintendent, Box 143, American Machinist.

065 Wanted—high grade foundry superintendent for machine-molding grey iron foundry; building and equipment new and up-to-date. Present daily capacity, 35 tons. A splendid opportunity for an advanced practical foundryman; exemplary character, good habits and executive ability essential. State full particulars, present salary, and references. Address, Superintendent, Box 143, American Machinist.

066 Reliable machinery salesman to travel in Spanish-speaking countries. Must be especially competent. Knowledge of Spanish a requisite.

MEN AVAILABLE

239 Assistant engineer of one of largest automobile plants. Eight years automobile experience in France and the United States. Commercial wagon work a specialty. Desires position as chief or assistant engineer in motor car works, preferably on business vehicles.

240 Member, civil and mechanical engineer, twenty-five years experience in general engineering, and eighteen years as specialist in dredging machinery and hydraulic dredges. Holds all world's records for hydraulic dredge performance, including best records on new Erie Canal. Will take entire charge of such department with large contracting firm.

241 Engineer, thirty years old, technical graduate, desires position as works manager, superintendent, or mechanical engineer with a moderate sized progressive concern. Shop and drafting work, devising and installing cost, shop and production systems, also experienced in electrical installations for industrial plants.

242 Junior member, forceful, wide-awake manager, of proven executive ability. Experience covers railroad shops, both locomotive and car, designing in drafting-room, and actual operation of a mainline division, selling and installing general machinery and gas-power plants, also allied railroad supplies. M. I. T. graduate; worked-up from shop apprentice, has successfully installed piece-work, bonus and cost systems, and is familiar with methods of bettering production. Can plan and carry out a business campaign. Unusual talent for organizing.

243 Member, of thorough mechanical and business training, good executive and organizer; at present employed as manager. Patentee many devices. Wishes to make a change.

244 Member, teacher in technical college, eight years experience in steel-mill, rolling-mill and bridge-shop designing, desires employment in the above or similar lines for three to four months, beginning about June 1, 1909.

245 Position as dean or director of a college of mechanical and electrical engineering, or head of a department in a large engineering school, by well-known

engineer actively engaged in mechanical engineering for ten years; present position dean of the college of mechanical and electrical engineering in one of our well-known universities, for the past eight years. Can furnish the best of references, including the administration and officers of this university. Only responsible position with bright future can be considered. Record is open to inspection by institution having the right kind of position to offer.

246 Position desired, by a member who has had a wide and varied experience in manufacturing and engineering, now qualifying under State Board of Law Examiners; wishes to engage in law office or with corporation requiring a legal and mechanical expert.

247 Junior, technical graduate, at present located in Middle West, desires position with engineering or manufacturing concern in New York City or Connecticut. Experienced in machine design and manufacture; position as assistant superintendent or chief draftsman preferred.

248 Engineer and superintendent, fifteen years experience in machine shop, engineering construction and design. Familiar with both Taylor and ordinary systems of management. At present in charge under a modification of the Taylor system. Competent and tactful, experienced in the installation of premium system and shop-betterment work.

249 Junior, desires position with engineering concern; seven years experience in engineering, has had charge of drafting room and erection. Familiar with modern office methods and books. Understands buying machinery, etc. At present assistant manager and assistant treasurer of an engineering concern. Prefers to locate in the vicinity of New York.

250 Member, long experience in pumping machinery, air compressors, Corliss engines, condensing apparatus; desires position as chief engineer or chief draftsman in neighborhood of New York City.

251 Stevens graduate wishes to become connected with department of experimental engineering. Broad practical experience.

252 Associate, age 32, experienced as inspecting mechanical and electrical engineer, desires similar position.

253 Mechanical graduate, general mechanical, electrical and construction experience, knowledge of engineering materials and contract practice, wishes position as assistant or executive in charge contract business.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ADAMS, Edward M. (1902), Ch. Engr., Quaker Oats Co., and *for mail,* 83 Charlotte St., Akron, O.

BACON, John Lord (Junior, 1899), Engr. and Supt. of Constr., R. P. Shields & Son, 605 Scripps Bldg., and *for mail,* 3435 D St., San Diego, Cal.

BAEHR, William Alfred (1903), 1943 Commercial Natl. Bank Bldg., Chicago, Ill.

BAILEY, Ervin G. (Junior, 1903), Mech. Engr., Fuel Testing Co., 220 Devonshire St., Boston, and 1057 Walnut St., Newton Highlands, Mass.

BECHTEL, John Adams (Associate, 1900), Williamsburg P. O., Va.

BIGELOW, Myron J. (1904), Mech. Engr., Molyneux Mailing Mchs. Co., 253 Ellicott St., and *for mail,* 357 Delaware Ave., Buffalo, N. Y.

BLOOMBERG, Jonas H. (1903), Cons. Engr., Avenida Del Cinco De Mayo No. 32, and *for mail,* Primera de Orizaba No. 11, Mexico City, D. F., Mexico.

BROWN, J. Linwood (1902), M. E., R. F. D. No. 1, Conneaut, Ashtabula Co., O.

CARLE, Nathaniel A. (1907), Box 32, Auraria, Ga.

CRANE, Edward S. (Associate, 1901), 3203 W. 14th St., Cleveland, O.

DAVIS, Chester B. (1890), 3353 6th Ave., Troy, N. Y.

FISHER, Henry Donald (Junior, 1907), Supervising Engr., U. S. Glass Co., Factory K, 18th and Merriman Ave., South Side, Pittsburg, Pa.

FOSTER, Ernest Howard (1885; 1894), Mech. Engr., V. P., Power Specialty Co., 111 Broadway, New York, N. Y.

FRANKS, Fredk. Benjamin (1904), 129 North West St., Allentown, Pa.

GOBEILLE, Jos. Léon (1886), Gobeille-Harris Pattern Co., Niagara Falls, N. Y.

GREEN, Samuel M. (1890), Cons. Engr., Hitchcock Bldg., 318 Main St., and 325 Long Hill St., Springfield, Mass.

GREENE, Harris Ray (Associate, 1907), Sales Engr., Alberger Condenser Co., 95 Liberty St., New York, N. Y., and 1406 Chapel St., New Haven, Conn.

GREENE, Isaac Chase (1882; 1886), Life Member, 29 W. 39th St., New York, N. Y.

GUELBAUM, David (1894; 1905), M. E., P. O. Box 293, Syracuse, N. Y.

HADDOCK, Edwin Jos. (1906), Mech. Engr., Schultz Bldg., Columbus, O.

HALL, Robert E. (1898; 1905), Asst. to V. P., Francis Bros. & Jellett, Inc., and *for mail,* 7802 Lincoln Drive, St. Martins, Philadelphia, Pa.

HARLAN, Orla K. (Junior, 1904), Dept. of Engrg. and Constr., Culebra, Canal Zone, Panama.

HELVEY, Geo. Stanley (Junior, 1904), 303 N. 2d St., Hamilton, O.

HODGE, Geo. O. (Junior, 1904), The Bristol Engrg. Corp., Bristol, Conn.

HUTCHISON, Arthur H. (1899), The C. W. Keltening Mercantile Co., 1617 Magee St., Denver, Colo.

JONES, Edward H. (1889), Clearwater, Fla.

KEITH, Thomas M. (Junior, 1905), Ch. Engr., Link Chain Belt Co., 52 Dey St., New York, and *for mail*, 241 Clinton Pl., Brooklyn, N. Y.

KENT, Robert Thurston (Junior, 1905), Managing Editor, Industrial Engineering, Empire Bldg., Pittsburg, Pa.

KLAHR, Charles Dean (Junior, 1905), Clarion, Pa.

KOON, Sidney Graves (Junior, 1905), The Hartford, Atwood St., Pittsburg, Pa.

LARDNER, Henry A. (1901), Mgr., J. G. White & Co. Inc., Alaska-Commercial Bldg., San Francisco, Cal.

LEMOINE, L. R. (Associate, 1887), Genl. Mgr., N. J. Zinc Co., 55 Wall St., and 161 Madison Ave., New York, N. Y., and 323 S. 18th St., Philadelphia, Pa.

MATTON, Fred V. (1892), Mech. Engr., Camden Iron Wks., Camden, N. J.

MERKT, Gustav A. (Associate, 1908), Designing Engr., Am. Steel and Wire Co., and *for mail*, 8 Blair St., Worcester, Mass.

MILLER, Frank Louis (Associate, 1907), 304 Everhart St., Johnstown, Pa.

MILLER, Fred J. (1890), Engineers' Club, 32 W. 40th St., New York, N. Y.

MURRAY, Arthur F. (Junior, 1908), Geo. F. Blake Mfg. Co., East Cambridge, Mass.

ORD, Henry C. (1905), Genl. Elec. Co., and *for mail*, 174 S. Common St., Lynn, Mass.

PITKIN, Joseph Lovell (Associate, 1903), Southern Rep., A. Klipstein & Co., 1622 Candler Bldg., Atlanta, Ga.

PRESSINGER, W. P. (Associate, 1903), W. P. Pressinger Co., 1 W. 34th St., New York, N. Y.

RATTLE, Paul S. (Junior, 1908), Sales Engr., The B. M. Osbun Co., 832 Commercial Natl. Bank Bldg., Chicago, Ill.

RIDDLE, Howard Sterling (1905), Wks. Mgr., Jeffrey Mfg. Co., Cote and Laganchiterre Sts., Montreal, Canada.

ROGERS, Robert W. (Junior, 1908), Pioneer Pub. Co., 1 Madison Ave., New York, N. Y.

SCHNUCK, Edward F. (1897; 1901), Production Engr., Director Jabez Burns & Sons, 600 W. 43d St., New York, N. Y.

SERGEANT, Chas. H. (1895), 611 W. 138th St., New York, N. Y.

STANTON, Frank McMillan (1892), Life Member, Room 409, 225 Fifth Ave., New York, N. Y.

STEVENS, Robt. H. (Junior, 1903), N. Y. Rep., Bethlehem Fdy. and Mch. Co., 149 Broadway, New York, and *for mail*, 780 E. 14th St., Flatbush, Brooklyn, N. Y.

STEVENS, Wm. N. (Junior, 1886), V. P., Conveying Mchy. Co., 120 Liberty St., New York, N. Y.

STOTT, Henry G. (1902), Mgr. 1907–1910; Supt. M. P., Interborough Rapid Transit Co., 600 W. 59th St., New York, and Rochelle Heights, New Rochelle, N. Y.

WARRINGTON, James N. (1884; 1885), 617 S. Grand Ave., Los Angeles, Cal.

WRAITH, William (1903), Supt., Washoe Smelter, P. O. Box 93, and 619 Main St., Anaconda, Mont.

NEW MEMBERS

JOHNSON, Louis L. (1908), The Westinghouse Mch. Co., Room 1412, N. Y. Life Bldg., Chicago, Ill.

MACLAREN, James G. (Associate, 1908), Engr., Lamson Cons. Store Service Co., Boston, and *for mail,* 109 Walter St., Roslindale, Mass.

SALTZMAN, Auguste L. (1908), Mech. Engr. and Supt., Cornwall, Plock & Saltzman, New York, N. Y., and *for mail,* 157 Central Ave., East Orange, N. J.

DEATHS

HILDRETH, Charles L.

RAND, Jasper R.

GAS POWER SECTION

CHANGES OF ADDRESS

BAEHR, William Alfred (1908), 1943 Commercial Natl. Bank Bldg., Chicago, Ill.

GREENE, Harris Ray (1908), Sales Engr., Alberger Condenser Co., 95 Liberty St., New York, N. Y., and 1406 Chapel St., New Haven, Conn.

LOZIER, Robert T. (Affiliate, 1908), Engineers' Club, 32 W. 40th St., New York, N. Y.

SERGEANT, Chas. H. (1908), 611 W. 138th St., New York, N. Y.

NEW MEMBERS

DANKS, Alfred C. (1909), Ch. Eng. of Gas Engines, Edgar Thomson Wks., Carnegie Steel Co., Braddock, and *for mail,* 331 West St., Wilkinsburg Sta., Pittsburg, Pa.

FISCHER, Wm. Francis (Affiliate, 1909), Engrg. Dept., N. Y. Edison Co., 55 Duane St., New York, N. Y.

HAYES, Frank A. (Affiliate, 1909), 409 Hartley Hall, Columbia Univ., New York, N. Y.

JACOB, Fred, Jr. (Affiliate, 1909), Estimating Engr., The Fairbanks Co., Broome and Lafayette Sts., New York, N. Y., and *for mail,* 110 Ridgewood Ave., Newark, N. J.

McNEIL, Merritt Chas. (Affiliate, 1909), Sales, R. D. Wood & Co., and *for mail,* 4834 Walton Ave., Philadelphia, Pa.

MYERS, Theodore B. (Affiliate, 1909), Gas Eng. Salesman, Otto Gas Eng. Wks., 138 Liberty St., New York, N. Y.

PRIDE, George H. (Affiliate, 1908), 277 Broadway, New York, N. Y.

RALSTON, Louis C. (Affiliate ,1909), 2613 Channing Way, Berkeley, Cal.

SEAGER, Schuyler F. (Affiliate, 1909). Secy. and Treas., Olds Gas Power Co., Lansing, Mich.

SUTER, John (Affiliate, 1909), care of F. P. Thorp, Internatl. Steam Pump Co., 115 Broadway, New York, N. Y.

WILE, Julius I. (1909), Sales Mgr., Producer Dept., Gas Mchy. Co., 56 Pine St., New York, N. Y.

WOLFE, Henry Geo. (Affiliate, 1909), Draftsman, N. Y. Edison Co., 55 Duane St., New York, and *for mail,* 65 Berkeley Pl., Brooklyn, N. Y.

COMING MEETINGS

Secretaries or members of societies whose meetings are of interest to engineers are invited to send in their notices for publication in this department. Such notices must be in the editor's hands by the 15th of the month preceding the meeting.

AERONAUTIC SOCIETY

May 12, etc., evenings, weekly meetings, Automobile Club of America, W. 54th St., New York. Secy., Wilbur R. Kimball.

AIR BRAKE ASSOCIATION

May 11–14, Annual Convention, Richmond, Va. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN ASSOCIATION OF DEMURRAGE OFFICERS

May 11, Southern Hotel, St. Louis, Mo., 10 a.m.

AMERICAN ASSOCIATION OF ELECTRIC MOTOR MANUFACTURERS

May 17–20, annual meeting, Hot Springs, Va.

AMERICAN CHEMICAL SOCIETY

May 14, New York section. Paper: Soluble and Fusible Condensation Products of Formaldehyde and Phenols, Dr. Baekeland. Secy., C. M. Joyce, Box 23, Arlington, N. J.

AMERICAN ELECTROCHEMICAL SOCIETY

May 5–8, annual meeting, Niagara Falls, Ont. Secy., Dr. J. W. Richards, Lehigh University, So. Bethlehem, Pa.

AMERICAN FOUNDRYMEN'S ASSOCIATION

May 18–20, Hotel Sinton, Cincinnati, O. Secy., Richard Moldenke, Watchung, N. J.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

June 24–25, semi-annual meeting, Brooklyn, N. Y. Secy., J. C. Olsen, Polytechnic Institute.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

May 18, monthly meeting, 33 W. 39th St., New York, 8 p. m. Paper: Patents, F. P. Fish. June 28, annual Convention, Frontenac, N. Y. Secy., R. W. Pope, 95 Liberty St. N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

May 21, monthly meeting, Toronto section. Secy. *pro tem*, W. H. Eisenheis, 1207 Traders' Bank Bldg.

AMERICAN RAILWAY ASSOCIATION

May 19, annual meeting, New York. Secy., W. F. Allen, 24 Park Pl.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

June 16–18, Annual Convention, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY OF CIVIL ENGINEERS

May 19, June 2, semi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

AMERICAN SOCIETY OF HUNGARIAN ENGINEERS AND ARCHITECTS
June 5, 29 W. 39th St., New York, 8.30 p.m. Secy., Zoltan de Nêmeth, 103 E. 16th St.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
May 4–7, Spring Meeting, Washington, D. C. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN SOCIETY OF SWEDISH ENGINEERS
May 1, May 15, semi-monthly meetings, Brooklyn, N. Y. Papers: May 1, The Austin Rotary Engine, Wm. K. Austin; May 15, Steam and its Behavior in Turbines, Ernst J. Berg. Secy., E. Hammerstrom, 271 Hicks St.

AMERICAN WATER WORKS ASSOCIATION
June 8–12, annual Convention, Milwaukee, Wis. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ARKANSAS ASSOCIATION OF PUBLIC UTILITY OPERATORS
May 12–14, Hot Springs. Secy., J. E. Cowles, Little Rock.

ASSOCIATION OF CAR LIGHTING ENGINEERS
June 7, semi-annual meeting, New York. Secy., G. B. Colgrove, I. C. R. R., Chicago, Ill.

ASSOCIATION OF RAILWAY CLUB SECRETARIES
June 19, annual meeting, Atlantic City, N. J.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS
June 23–25, Detroit, Mich. Secy., P. W. Drew, Room 511, Harvester Bldg., Chicago, Ill.

BLUE ROOM ENGINEERING SOCIETY
June 3, monthly meeting, 29 W. 39th St., New York, 8 p.m. Secy., W. D. Sprague.

BOSTON SOCIETY OF CIVIL ENGINEERS
May 19, monthly meeting, Tremont Temple. Secy., S. E. Tinkham, 60 City Hall.

BROOKLYN ENGINEERS' CLUB
May 6, 117 Remsen St. Paper: The Oxy-Acetylene Welding Process. Henry R. Cobleigh. Secy., Joseph Strachan.

CANADIAN ELECTRICAL ASSOCIATION
June 16–18, annual Convention, Quebec. Secy., T. S. Young, Confederation Life Bldg., Toronto.

CANADIAN GAS ASSOCIATION
June 25, annual meeting, Toronto, Ont. Secy. A. W. Moore, Woodstock.

CANADIAN SOCIETY OF CIVIL ENGINEERS, Toronto Branch, May 27, regular meeting, 96 King St., W. Secy., T. C. Irving, Jr.

CAR FOREMEN'S ASSOCIATION OF CHICAGO
May 10, monthly meeting, Masonic Temple. Secy., Aaron Kline, 326 N. 50th St.

CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA
May 18, monthly meeting, Rossin House, Toronto, Ont. Secy., C. L. Worth, Room 409, Union Sta.

CENTRAL RAILWAY CLUB
May 14, monthly meeting, Hotel Iroquois, Buffalo, N. Y., 8 p.m. Secy., H. D. Vought, 95 Liberty St., New York.

CHICAGO ELECTRIC CLUB

May 12, etc., weekly meetings, noon, Chicago Automobile Club. Secy., W. S. Taussig, 204 Dearborn St.

CIVIL ENGINEERS' CLUB OF CLEVELAND

May 11, June 8, monthly meetings, 714–719 Caxton Bldg., Secy., J. C. Beardley.

CIVIL ENGINEERS' CLUB OF ST. PAUL

May 10, June 7, monthly meetings. Secy , G. E. Edmonstone.

CLEVELAND ENGINEERING SOCIETY

May 11, monthly meeting, Caxton Bldg. Secy., Joe C. Beardsley.

COLORADO SCIENTIFIC SOCIETY

June 5, monthly meeting, Denver. Secy., Dr. W. A. Johnston, 801 Symes Bldg.

DENVER SOCIETY OF CIVIL ENGINEERS

May 11, June 8, monthly meetings, 36 Jacobson Bldg. Secy., Walter Pearl.

EASTERN RAILROAD ASSOCIATION

May 13, annual meeting. Secy., John J. Harrower, 614 F St. N. W., Washington, D. C.

ENGINEERING ASSOCIATION OF THE SOUTH

May 18, monthly meeting. Secy., H. M. Jones, 2 Berry Blk., Nashville, Tenn.

ENGINEERING SOCIETY OF THE STATE UNIVERSITY OF IOWA

June 1, monthly meeting, Iowa City. Secy., Dean Wm. G. Raymond.

ENGINEERS AND ARCHITECTS' CLUB OF LOUISVILLE, KY.

May 17, monthly meeting, 303 Norton Bldg. Secy., Pierce Butler.

ENGINEERS' CLUB OF BALTIMORE

June 5, annual meeting. Secy., R. K. Compton, City Hall.

ENGINEERS' CLUB OF CENTRAL PENNSYLVANIA

June 1, annual meeting, Gilbert Bldg., Harrisburg. Secy., E. R. Dasher.

ENGINEERS' CLUB OF CHICAGO

May 18, June 1, semi-monthly meetings, Jefferson Hall, 70 Adams St. Secy., D. W. Thurtell, 1223 New York Life Bldg.

ENGINEERS' CLUB OF CINCINNATI

May 20, monthly meeting, 25 E. 8th St. Secy., E. A. Gast, P. O. Box 333.

ENGINEERS' CLUB OF MINNEAPOLIS

May 17, monthly meeting, City Hall.

ENGINEERS' CLUB OF PHILADELPHIA

May 15, June 5, semi-monthly meetings, 1122 Girard St. Secy., W. L. Webb.

ENGINEERS' CLUB OF ST. LOUIS

May 19, June 2, semi-monthly meetings, 3817 Olive St. Secy., R. H. Fernald.

ENGINEERS' CLUB OF TORONTO

May 13, etc., weekly meetings, 96 King St., W. Secy., R. B. Woolsey.

ENGINEERS' SOCIETY OF MILWAUKEE

May 12, monthly meeting, 456 Broadway. Secy., W. Fay Martin.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

May 18, regular meeting; May 20, Chemical section; May 25, Structural section; June 1, Mechanical section; 803 Fulton Bldg., Pittsburgh. Secy., Edmund Yardley.

EXPLORERS' CLUB

June 4, 29 W. 39th St., New York, 8.30 p.m. Secy., H. C. Walsh.

FREIGHT CLAIM ASSOCIATION

June 16, annual meeting, Old Point Comfort, Va. Secy., W. P. Taylor, Richmond, Va.

FOUNDRY AND MANUFACTURERS' SUPPLY ASSOCIATION

May 17–22, annual meeting and exhibit, Cincinnati, O. Secy., C. E. Hoyt, Lewis Institute, Chicago, Ill.

GENERAL MANAGER'S ASSOCIATION OF CHICAGO

May 20, monthly meeting. Secy., H. Deeming.

GENERAL SUPERINTENDENTS' ASSOCIATION OF CHICAGO

May 19, Chicago. Secy., H. D. Judson, C. B. & Q. R. R.

ILLUMINATING ENGINEERING SOCIETY

May 13, monthly meeting, New York section, 29 W. 39th St., 8 p.m. Secy., P. S. Millar.

INTERNATIONAL RAILWAY FUEL ASSOCIATION

June 21–23, annual meeting, Auditorium Hotel, Chicago, Ill. Secy., D. B. Sebastian, 327 La Salle St. Sta., Chicago.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION

June 1–5, annual meeting, Chicago, Ill. Secy., E. C. Cook, Royal Insurance Bldg.

IOWA DISTRICT GAS ASSOCIATION

June 23–25, annual meeting, Waterloo, Ia. Secy., G. I. Vincent, Des Moines.

IOWA RAILWAY CLUB

May 14, monthly meeting, Des Moines. Secy., W. B. Harrison, Union Sta.

LOUISIANA ENGINEERING SOCIETY

May 10, monthly meeting, 323 Hibernia Bldg., New Orleans. Secy., L. C. Datz.

MASSACHUSETTS STREET RAILWAY ASSOCIATION

May 13, June 9, monthly meetings, Boston. Secy., Chas. S. Clark, 70 Kilby St.

MASTER CAR BUILDERS' ASSOCIATION

June 21–23, annual Convention, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER MECHANICS ASSOCIATION

June Convention, Atlantic City, N. J.

MODERN SCIENCE CLUB

May 4, weekly meeting, 125 S. Elliott Pl., Brooklyn, N. Y. Paper: Autogenous Welding with Oxy-Acetylen, E. Bournvonville. May 8, Papers: House-Heating Boilers, May 22, Papers: Turbine Governors. May 25, Papers: Elevator Accidents and their Prevention, F. E. Town. Secy., Jas. A. Donnelly.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

May 26, 29 W. 39th St., 8.15 p.m. Secy., C. D. Pollock.

NATIONAL ASSOCIATION OF AUTOMOBILE MANUFACTURERS

June 2, monthly meeting, New York. Secy., C. C. Hildebrand, 7 E. 42d St.

NATIONAL ASSOCIATION OF MANUFACTURERS

May 17–19, Convention, Waldorf-Astoria, New York. Secy., Geo. S. Boudinot, 170 Broadway.

NATIONAL ELECTRIC LIGHT ASSOCIATION

June 1–4, Atlantic City, N. J. Secy., John F. Gilchrist, 29 W. 39th St., New York.

NATIONAL FIRE PROTECTION ASSOCIATION

May 25–27, annual meeting, 32 Nassau St., New York. Papers: Recent efforts to create the office of State Fire Marshal, Clarence Maris; Concrete Building Construction, Leonard C. Wason, The New York High-Pressure System, Alfred G. Patton, Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

NATIONAL GAS AND GASOLENE ENGINE TRADES ASSOCIATION

June 22–24, Oliver Hotel, South Bend, Ind. Secy., A. Stritmatter, Cincinnati, Ohio.

NATURAL GAS ASSOCIATION OF AMERICA

May 18–21, Annual Convention, Goodale St. Auditorium, Columbus, O. Secy., L. S. Bigelow, 265 Broadway, New York.

NEW ENGLAND RAILROAD CLUB

May 11, monthly meeting, Copley Square Hotel, Boston, Mass., 8 p.m. Secy., Geo. H. Frazier, 10 Olive St.

NEW ENGLAND STREET RAILWAY CLUB

May 27, monthly meeting, American House, Boston, Mass. Secy., John J. Lane, 12 Pearl St.

NEW YORK RAILROAD CLUB

May 21, monthly meeting, 29 W. 39th St., 8.15 p.m. Secy., H. D. Vought, 95 Liberty St.

NEW YORK SOCIETY OF ACCOUNTANTS AND BOOKKEEPERS

May 11, etc., weekly meetings, 29 W. 39th St., 8 p.m. Secy., T. L. Woolhouse.

NEW YORK TELEPHONE SOCIETY

May 18, monthly meeting, 29 W. 39th St., 8 p.m. Secy. T. H. Laurence.

NORTHERN RAILWAY CLUB

May 22, monthly meeting, Commercial Club Rooms, Duluth, Minn. Secy., C. L. Kennedy.

NORTHWEST RAILWAY CLUB

May 11, monthly meeting, St. Paul, Minn. Secy., T. W. Flannagan, care Soo Line.

NOVA SCOTIA SOCIETY OF ENGINEERS

May 13, monthly meeting, Halifax. Secy., S. Fenn.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

May 21, 22, spring meeting, Canton. Secy., David Gaehr, Schofield Bldg., Cleveland.

OPTOMETRICAL SOCIETY OF THE CITY OF NEW YORK

May 12, June 9, monthly meetings, 29 W. 39th St., 8 p.m. Secy., J. H. Drakeford.

PACIFIC COAST RAILWAY CLUB

May 15, monthly meeting, San Francisco, Cal. Secy., E. C. Borton, West Oakland, Cal.

PROVIDENCE ASSOCIATION OF MECHANICAL ENGINEERS

May 25, monthly meeting, Technical High School Hall, 8 p.m. June 22, annual meeting. Secy., T. M. Phetteplace.

PURDUE MECHANICAL ENGINEERING SOCIETY

May 12, etc., fortnightly meetings, Purdue University, Lafayette, Ind., 6.30 p.m. Secy., L. B. Miller.

RAILWAY CLUB OF KANSAS CITY

May 21, 904 Delaware St. Secy., Claude Manlove.

RAILWAY CLUB OF PITTSBURGH

May 28, monthly meeting, Monongahela House, 8 p.m. Secy., J. D. Conway, Genl. Office, P. & L. E. R. R.

RAILWAY SIGNAL ASSOCIATION

June 8, 29 W. 39th St., New York, 10 a.m. Secy., C. C. Rosenberg, 712 North Linden St., Bethlehem, Pa.

RAILWAY STOREKEEPERS' ASSOCIATION

May 17–19, annual meeting, Chicago, Ill. Secy., J. P. Murphy, L. S. & M. S. Ry., Collingwood, O.

RENSSELAER SOCIETY OF ENGINEERS

May 21, etc., fortnightly meetings, 257 Broadway, Troy, N. Y. Secy., R. S. Furber.

ROCHESTER ENGINEERING SOCIETY

May 14, monthly meeting. Secy., John F. Skinner, 54 City Hall.

ROCKY MOUNTAIN RAILWAY CLUB

May 15, monthly meeting. Secy., J. E. Buell, Denver, Colo.

ST. LOUIS RAILWAY CLUB

May 14, monthly meeting, Southern Hotel, 8 p.m. Secy., B. W. Frauenthal, Union Sta.

SCRANTON ENGINEERS' CLUB

May 20, monthly meeting, Board of Trade Bldg. Secy., A. B. Dunning.

SHORT LINE RAILROAD ASSOCIATION

June 7, New York. Secy., John N. Drake, 60 Wall St.

SOUTHWESTERN ELECTRICAL AND GAS ASSOCIATION

May, Annual Convention, Dallas, Texas.

TECHNICAL SOCIETY OF BROOKLYN

May 15, June 4, semi-monthly meetings. Arion Hall, Arion Pl., 8.30 p.m. Pres., M. C. Budell, 20 Nassau St., New York.

TECHNOLOGY CLUB OF SYRACUSE

May 12, monthly meeting, 502 Bastable Blk., 8 p.m. Secy., Robert L. Allen.

TECHNICAL SOCIETY OF THE PACIFIC COAST

June 4, San Francisco, Cal. Secy., Otto von Geldern, 1978 Broadway.

TRAIN DESPATCHERS' ASSOCIATION OF AMERICA

June 15, annual Convention, Columbus, O. Secy., J. F. Mackie, La Salle St. Sta., Chicago, Ill.

WESTERN RAILWAY CLUB

May 18, monthly meeting, Auditorium Hotel, Chicago, Ill., 8 p.m. Secy., Joseph W. Taylor, 390 Old Colony Bldg.

WESTERN SOCIETY OF ENGINEERS

May 19, etc., fortnightly meetings, May 12, Electrical section, Chicago, Ill. Secy., J. H. Warder, 1737 Monadnock Blk.

WIRELESS INSTITUTE

June 2, 29 W. 39th St., New York. Secy., S. L. Williams.

WISCONSIN GAS ASSOCIATION

May 12, 13, annual Convention, Milwaukee. Secy., Henry H. Hyde, Racine

MEETINGS TO BE HELD IN ENGINEERING SOCIETIES' BUILDING

Date	Society	Secretary	Time
May			
11	N. Y. Society Accountants and Bkprs.	T. L. Woolhouse	8:00
12	Optometrical Society of the City of N. Y.	J. H. Drakeford	8:00
13	Illuminating Engineering Society	P. S. Millar	8:00
18	N. Y. Society Accountants and Bkprs.	T. L. Woolhouse	8:00
18	New York Telephone Society	T. H. Laurence	8:00
18	American Institute Electrical Engineers	R. W. Pope	8:00
19	American Railway Association	W. F. Allen	All day
21	New York Railroad Club	H. D. Vought	8:15
25	N. Y. Society Accountants and Bkprs.	T. L. Woolhouse	8:00
26	Municipal Engineers of City of New York	C. D. Pollock	8:15
June			
1	N. Y. Society Accountants and Bkprs.	T. L. Woolhouse	8:00
2	Wireless Institute	S. L. Williams	7:30
3	Blue Room Engineering Society	W. D. Sprague	8:00
4	Explorers' Club	H. C. Walsh	8:30
5	Amer. Soc. Hungarian Engrs. and Archts.	Z. de Németh	8:30
8	N. Y. Society Accountants and Bkprs.	T. L. Woolhouse	8:00
8	Railway Signal Association	C. C. Rosenberg	1:00 a. m.
9	Optometrical Society of City of N. Y.	J. H. Drakeford	8:00

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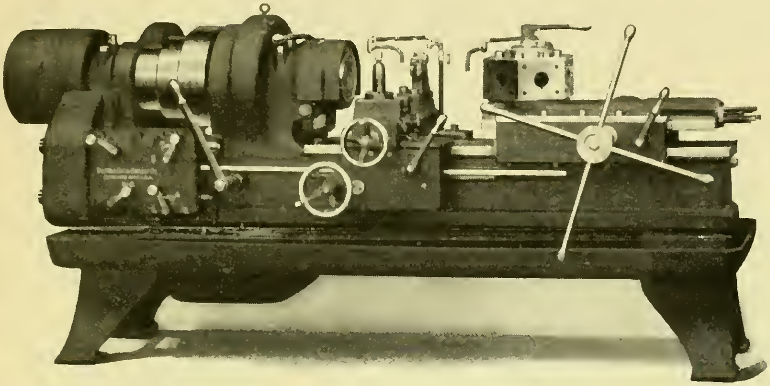

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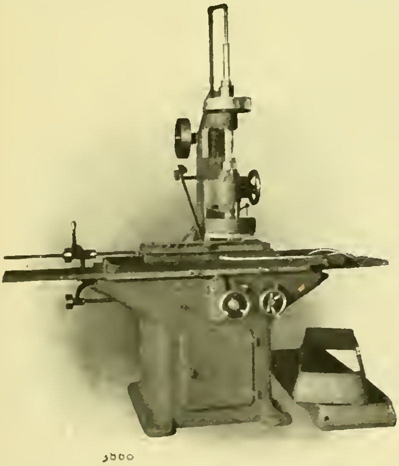

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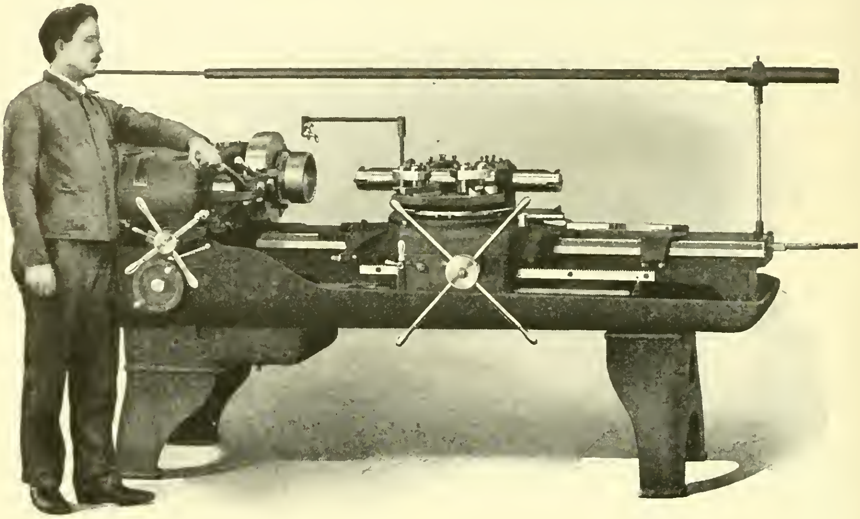

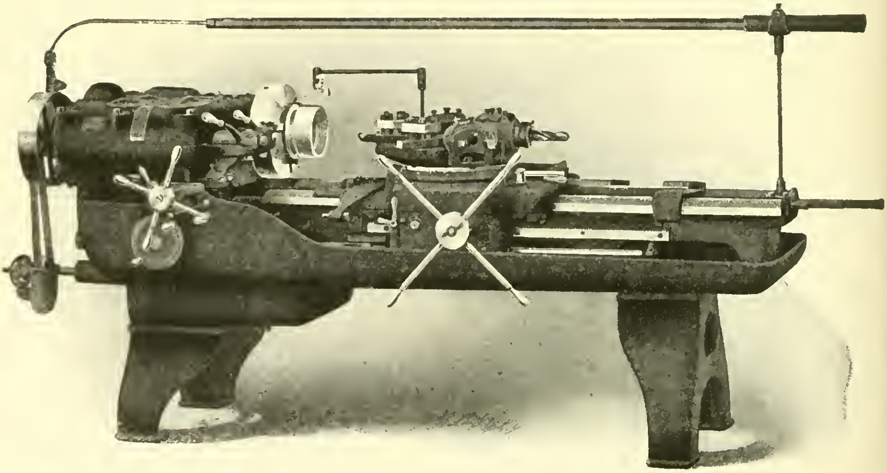

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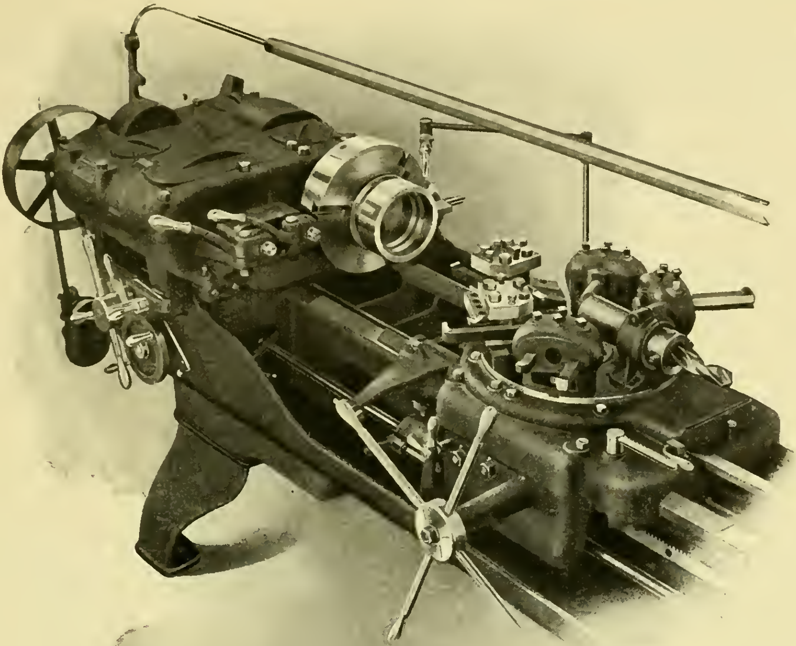

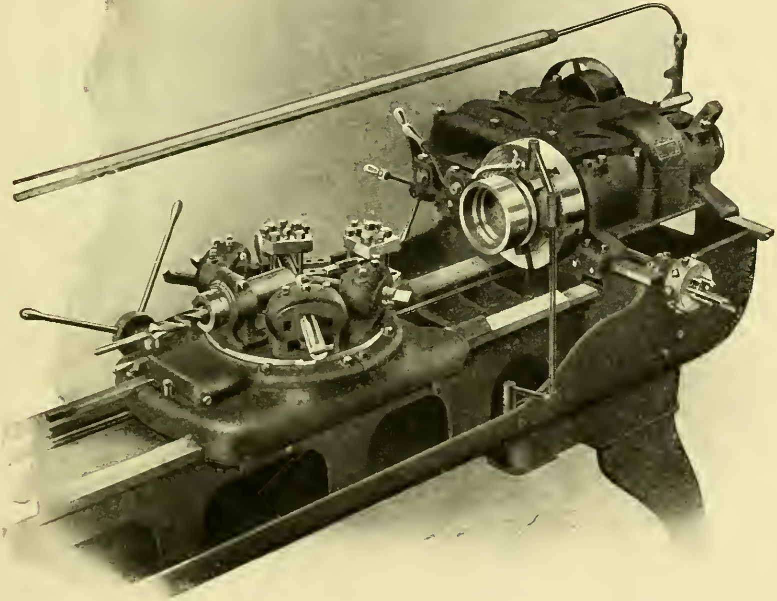

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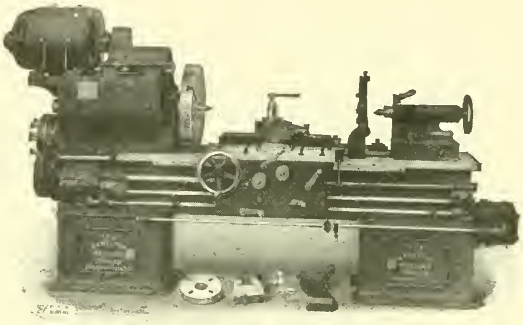

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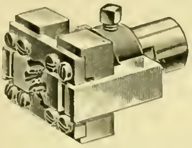

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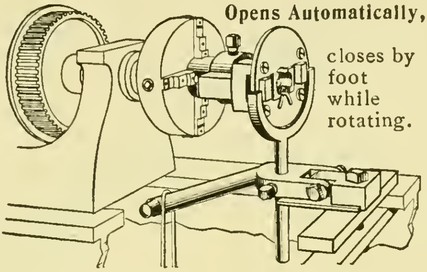

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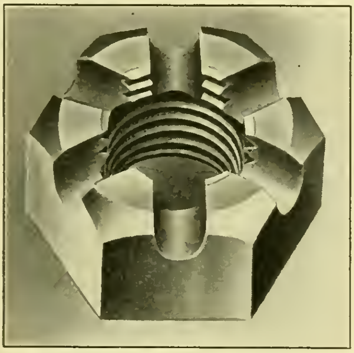

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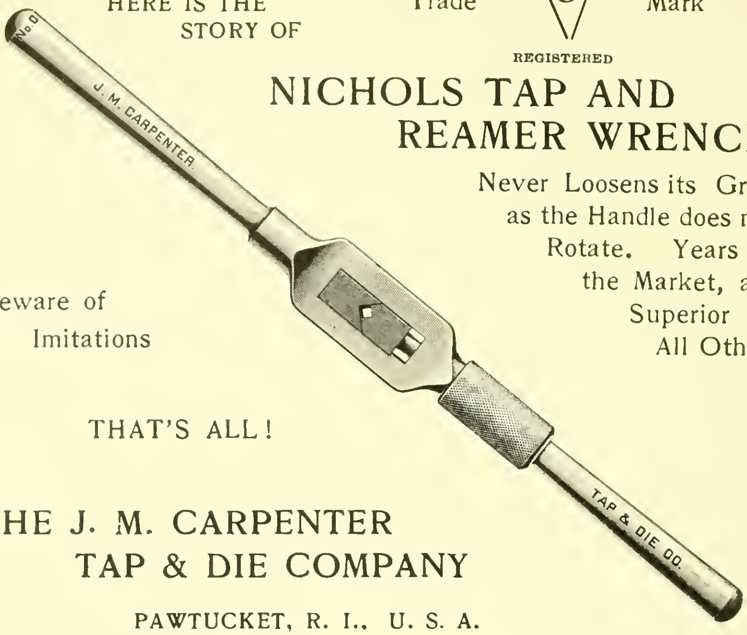

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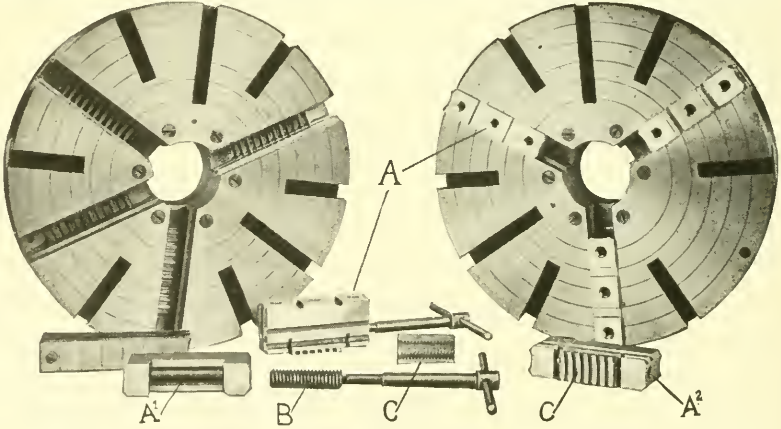

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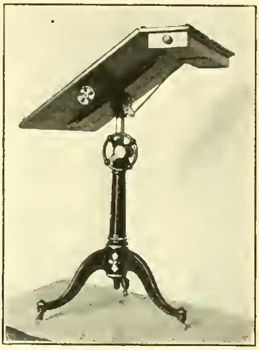

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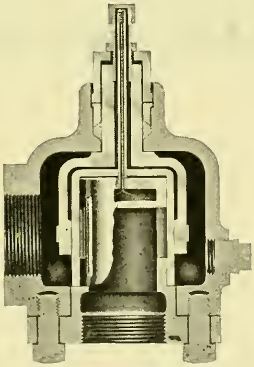

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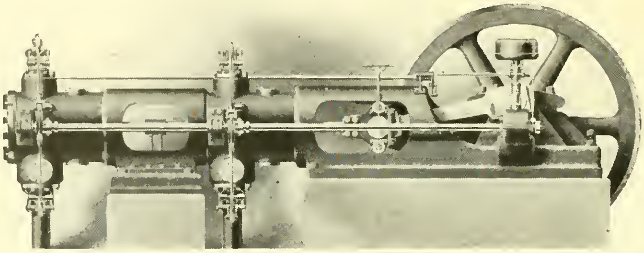

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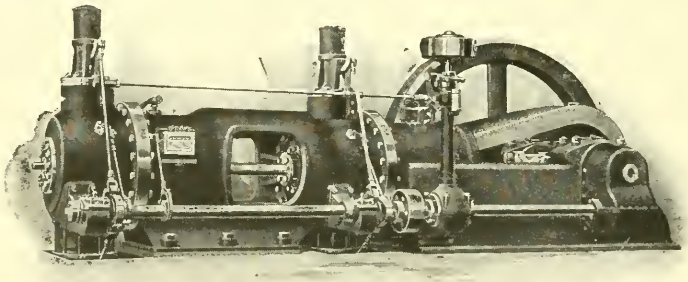

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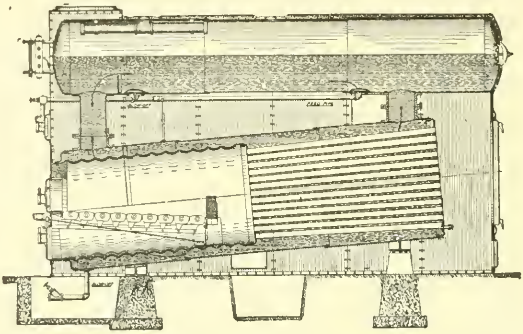

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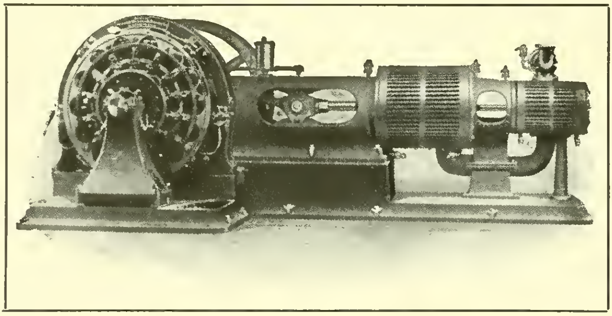

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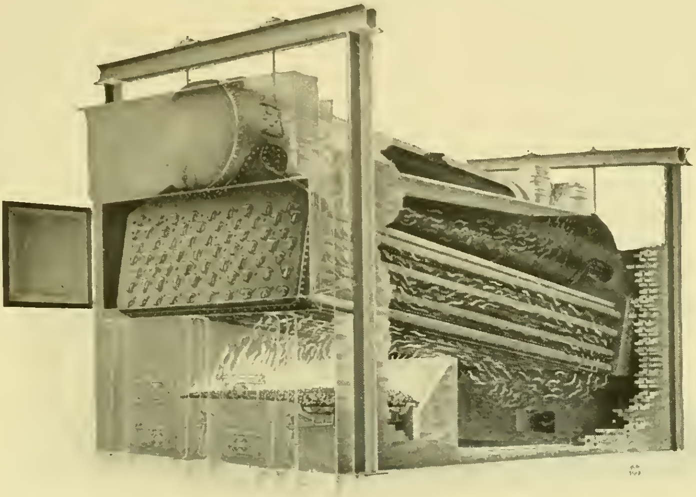

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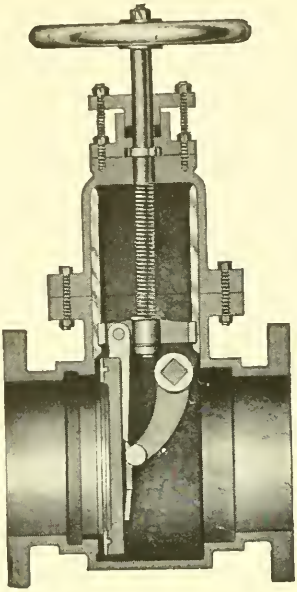

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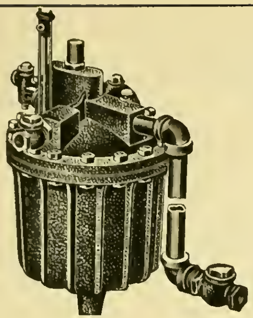

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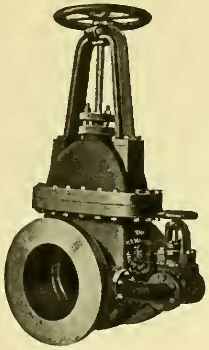

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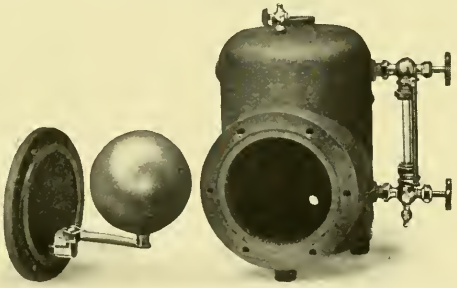

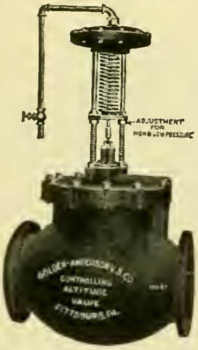

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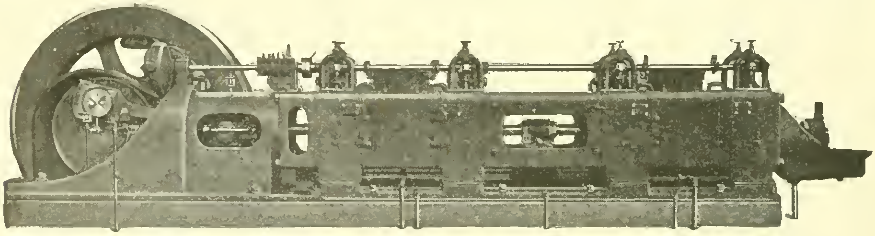

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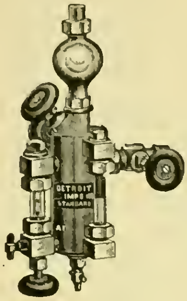

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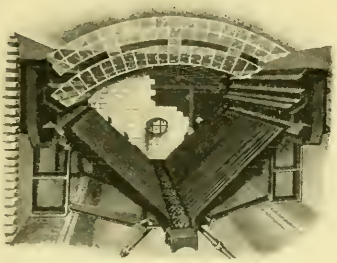

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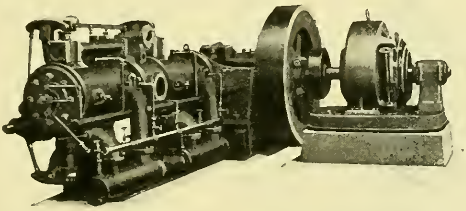

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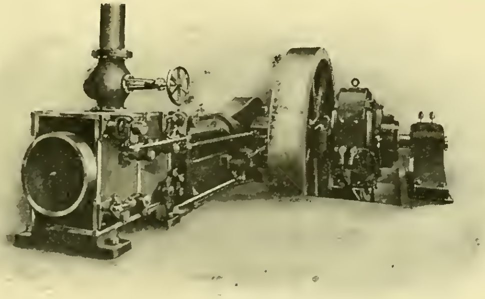

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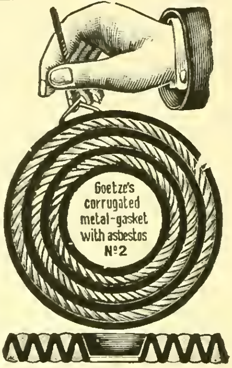

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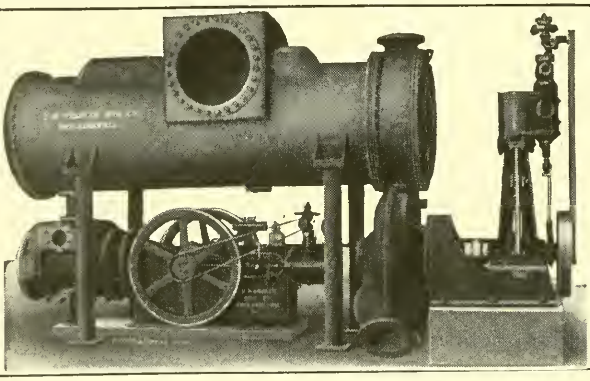

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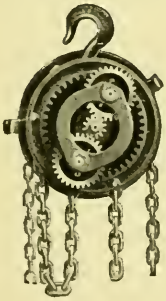

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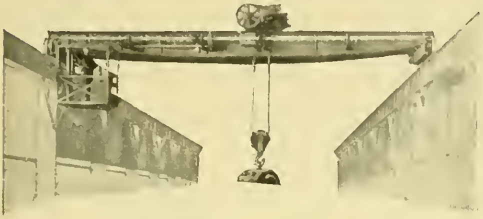

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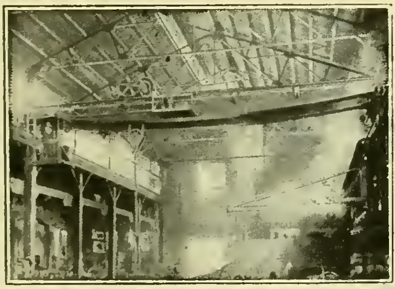

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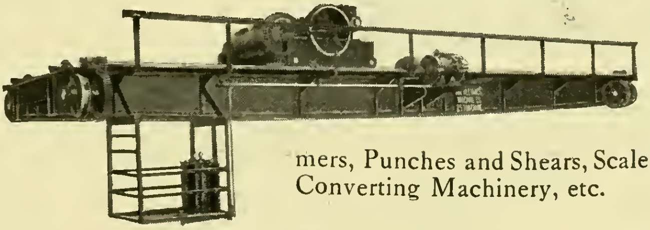

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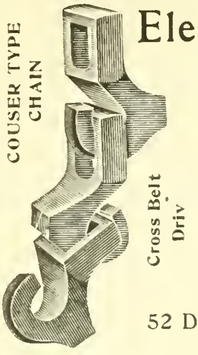

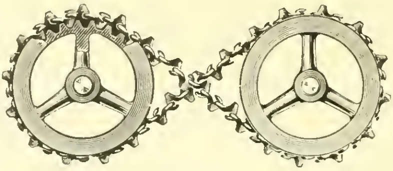

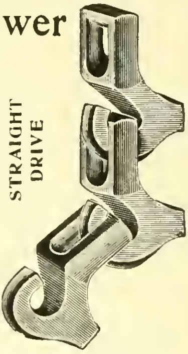

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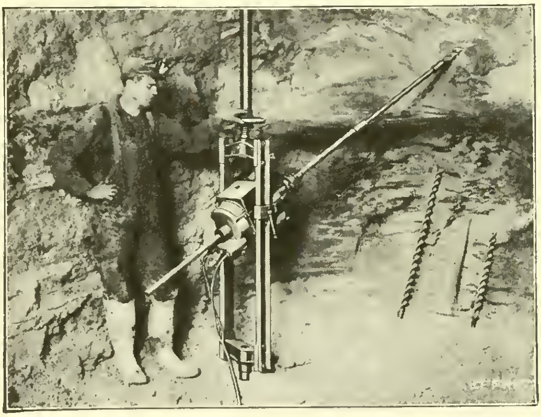

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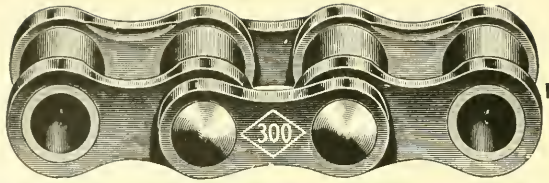

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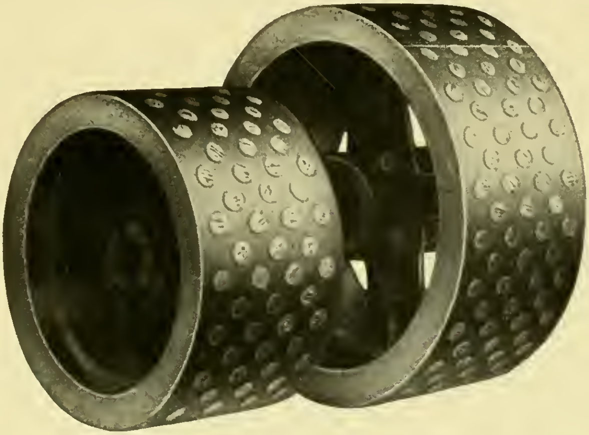

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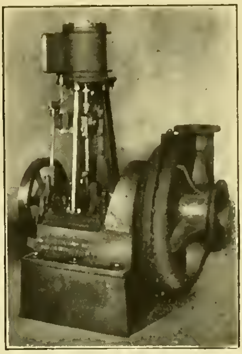

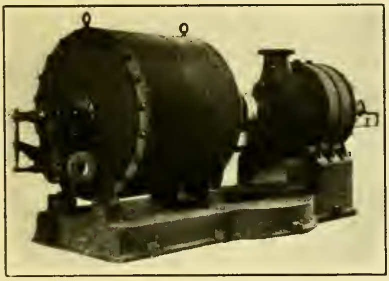

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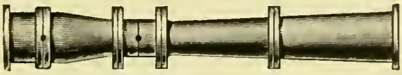

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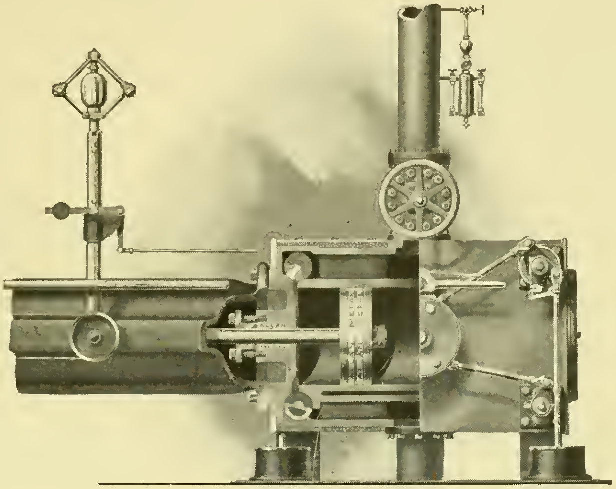

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Link Chain Belt Co., New York.

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Morris Machine Works, Baldwinsville, N. Y.
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Ridgway Dynamo & Engine Co., Ridgway, Pa.
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WINCHES.

Yale and Towne Mfg. Co., New York.

ALPHABETICAL LIST OF ADVERTISERS

Page
Albany Steam Trap Co........... 15
Allan & Son, A.................. 29
Alliance Machine Co............. 21
American Engine Co............. 16
American Gas Furnace Co........ 8
American Goetze-Gasket & Packing Co........................... 18
American Swiss File & Tool Co..... 7
Arnold Co., The 30

Bacon, Earle C................... 30
Baldwin, Bert. L................. 30
Buckeye Engine Co.............. 10
Builders Iron Foundry........... 27

Carpenter Tap & Die Co., J. M..... 6
Carrier Air Conditioning Co....... 29
Clarkson School of Technology.... 30
Cleveland Crane & Engineering Co. 21
Conard, William R 30

Detroit Lubricator Co............ 17
Detroit Stoker & Foundry Co...... 17
Diamond Chain and Mfg. Co...... 24
Dixon Crucible Co., Joseph........ 18
Dodge Co., J. M.................. 21
Dodge Mfg. Co.................... 23
DuBois Iron Works.............. 17

Electric Controller & Mfg. Co...... 19
Engineering Schools and Colleges.. 30
Errington, F. A................. 5

General Electric Co.............. 4
Golden-Anderson Valve Specialty Co.......................... 15

Heine Safety Boiler Co........... 16
Hooven, Owens & Rentschler Co.. 17
Hurley & Co., D 30

Jeanesville Iron Works Co........ 27
Jeffrey Mfg. Co.................. 22
Jones & Lamson Machine Co......2-3

Kennedy Valve Mfg. Co.......... 15
Kerr Turbine Co.................. 27

Lindstrom, John T............... 15
Link-Belt Co..................... 20
Link Chain Belt Co..............22

Page
Main, Chas. T.................... 30
Manning, Maxwell & Moore....... 5
Mason Regulator Co.............. 9
Morris Machine Works........... 27
Morse Twist Drill & Machine Co... 7
Murray Iron Works Co........... 13

National Brake & Clutch Co..... 25
National Machinery Co........... 5
National Meter Co............... 13
Nelson Valve Co................. 11
Newark Gear Cutting Machine Co.. 7
New York University School of Applied Science............... 30

O'Neill, J. G.................... 30

Polytechnic Institute of Brooklyn.. 30
Pratt & Whitney Co.............. 1
Professional Cards............... 30

Reichhelm & Co., E. P............ 7
Rensselaer Polytechnic Institute .. 30
Ridgway Dynamo & Engine Co.... 12
Riverside Engine Co.............. 16
Robb-Mumford Boiler Co......... 12
Roebling's Sons Co., John A...... 20
Russell, Burdsall and Ward Bolt and Nut Co.................. 5

Seneca Falls Mfg. Co............. 8
St. Louis Iron & Machine Works... 16
Simmons Co., John 9
Standard Tool Co..................7
Struthers-Wells Co............... 10

Tufts College.................... 30

University of Michigan............ 30

Walch & Wyeth.................. 14
Warner & Swasey Co............. 1
Washburn Shops................. 8
Wheeler Mfg. Co., C. H........... 18
Whiting Foundry Equipment Co.. 21
Whiton Machine Co., D. E........ 6
Williams & Wilkins Co........... 22
Wisconsin Engine Co............. 9
Yale and Towne Mfg. Co.........19

021

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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JUNE 1909

NEXT MONTHLY MEETING, OCTOBER 12

JUNE 1909 VOL. 31 No. 6

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLISHED AT 2427 YORK ROAD - - - - BALTIMORE, MD.
EDITORIAL ROOMS, 29 W. 39TH STREET - - - - NEW YORK

CONTENTS

SOCIETY AFFAIRS 3
Washington Meeting (3), Meeting of the Society in Boston (13), Communication from the Meetings Committee (17), Advisory Committee on Fuels and Structural Materials (20), Minutes of the Council (22), General Notes (25), Other Societies (30), Personals (34).
SOCIETY HISTORY 727
PRESENTATION ADDRESSES
Engineering in the U. S. Navy, G. W. Melville 731
George Wallace Melville, W. M. Macfarland 736
Acceptance of Portrait, C. D. Walcott 739
DISCUSSION
Carbonic Acid and its Storage, R. T. Stewart. J. C. Minor, Jr., H. E. Stürcke, Graham Clarke, L. H. Thullen, E. D. Meier, S. A. Moss, Wm. Kent, the Author 741
Fuel Economy Tests, C. R. Weymouth. W. B. Gregory, the Author 755
Articulated Compound Locomotives, C. J. Mellin. F. J. Cole, Harrington Emerson, L. R. Pomeroy, G. L. Fowler, G. R. Henderson, Alfred Lovell, S. M. Vauclain, G. H. Emerson, the Author ....
Surge Tank in Water Power Plants, R. D. Johnson, Closure 783
Safety Valves, F. L. Pryor, E. F. Miller, G. H. Musgrave, A. B. Carhart, S. B. Paine, M. W. Sewall, A. C. Ashton, A. F. Nagle, J. J. Aull, A. J. Hewlings, F. M. Whyte, P. G. Darling 785
ACCESSIONS TO THE LIBRARY 807
EMPLOYMENT BULLETIN 811
CHANGES IN MEMBERSHIP 815
COMING MEETINGS 824
OFFICERS AND COMMITTEES 830

THE JOURNAL is published by The American Society of Mechanical Engineers twelve times a year, monthly except in July and August, semi-monthly in October and November.
Price, one dollar per copy—fifty cents per copy to members. Yearly subscription, $7.50; to members, $5.

Application filed for entry at the Postoffice, Baltimore, Md. as second-class mail matter under the act of March 3, 1879

The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL
OF
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

VOL. 31 JUNE 1909 NUMBER 6

THE SPRING MEETING

The Spring Meeting was held in Washington, D. C., at the New Willard Hotel, May 4–7. The total registration was 609, of whom 276 were members. Fewer professional sessions than usual were arranged by the Meetings Committee in order that visiting members and their guests might avail themselves of the opportunities afforded to inspect places of interest at the national capital.

The Convention opened on Tuesday evening with a reception in the large assembly hall of the New Willard, followed by dancing, with music by the Marine Band. The reception was largely attended and the occasion was a brilliant one. As the guests arrived they were received by the President and Mrs. Smith, Mrs. W. L. Marshall, Mrs. Charles D. Walcott, and Mrs. F. H. Newell.

D. S. Carll, President of the Washington Society of Engineers, called the assembly to order at 9 o'clock, and extended a hearty welcome to the Society on behalf of its local members and of the Washington Society of Engineers. He then introduced Hon. Henry B. F. Macfarland, President of the Board of Commissioners of the District of Columbia.

Speaking on behalf of these same bodies and of the District of Columbia, Mr. Macfarland referred especially to the work of engineers in the city of Washington, and said in part: There is a particularly warm welcome for the Society in the national capital, since engineers more than the men of any other profession have made it what it is. George Washington, in the year of the birth of the Constitution, conceived the idea of a magnificent capital, then ridiculously out of proportion to the youth, weakness and poverty of the new nation. L'Enfant and Ellicott in the beginning, and a long line of able and brilliant engineers since then, chiefly of the United States Army, have rendered important servce in carrying out his plans. The past nine years, the great municipal building period of the city, have been occupied with such engineering feats as the installation of the filtration plant, the sewage disposal system, the new pumping system, the District government railway terminal work, the District government building on Pennsylvania Avenue and its approaches, the Connecticut Avenue bridge, and others of a similar character. Washington appreciates engineers.

President Smith in responding for the Society extended the thanks of the members for this cordial welcome and their appreciation of the interesting program prepared for their pleasure and entertainment by the committees of the Washington Society of Engineers and of the local members.

RECEPTION COMMITTEE FOR TUESDAY EVENING

The following prominent engineers constituted the reception committee for Tuesday evening:

Lieut. Col. Frederic V. Abbot, Corps of Engrs., U. S. A., Office Ch. of Engrs.; Walter C. Allen, Elec. Engr., Dist. of Columbia; Frank L. Averill, Cons. Engr.; Philander Betts, Asst. Prof. Elec. Engrg., Geo. Washington University; Louis D. Bliss, Pres., Bliss Sch. of Elec.; Rear-Admiral Washington L. Capps, Ch., Bureau Constr. and Repair, Navy Dept.; David S. Carll, V. P. & Gen. Mgr., Capital Traction Co.; Brig. Gen. William Crozier, Ch. of Ordnance, U. S. Army; Arthur P. Davis, Ch. Engr., Reclamation Service; David T. Day, Petroleum Expt., Geolog. Survey; Capt. J. B. Dillard, Ordnance Dept., U. S. Army; Proctor L. Dougherty, Asst. Insp. Elec. Light Plants, Treas. Dept.; Robert Farnham, Jr., Asst. Engr. of Constr., Penna. R. R.; Harry W. Fuller, Gen. Mgr., Washington Ry. and Elec. Co.; Howard L. Hodgkins, Dean, College of Engrg., Geo. Washington University; John C. Hoyt, Asst. Ch. Hydrographer, U. S. Geol. Survey; Ernest N. Janson, Mech. Engr., Navy Dept.; Capt. William Kelly, Corps of Engrs., U. S. A., Asst. to Engrg. Commissioner, D. C., Charles S. Kimball, Engr. Maintenance of Way, Wash. Ry. & Elec. Co.; Marshall O. Leighton, Ch. Hydrographer, U. S. Geol. Survey; Charles A. McKenney, Cons. Engr.; Hon. Robert Shaw Oliver, Asst. Secy. of War; Alfred H. Raynal, Mech. Engr., Navy Dept.; 1st Lieut. William H. Rose, Corps of Engrs., U. S. A.; William E. Schoenborn, Expt. in Pat. Causes; Lindley E. Sinclair, Gen. Supt., Potomac Elec. Power Co.; Charles F. Sponsler, Ch. Engr., Bureau of Standards; Lt. Col. Thomas W. Symons, Advisory Board, Cons. Engr., State Canals, N. Y.; O. H. Tittman, Ch., Coast & Geodetic Survey; Francis R. Weller, Civil and

Hyd. Engr.; Herbert M. Wilson, Ch. Engr., Tech. Branch, U. S. Geolog. Survey; Brig. Gen. James B. Aleshire, Quartermaster Gen., U. S. A.

Business Meeting Wednesday Morning, May 5

The report of the tellers of election was received and there being no objection the President declared the names presented duly elected to membership in the Society. They will be published in The Journal in the usual department for changes in membership.

A report from the Membership Committee was presented which calls for amendments to C 10 and C 11 of the constitution. The first amendment is as follows:

> C 10 "An Associate shall be 30 years of age or over. He must have been so connected with some branch of engineering, or science, or the arts, or industries, that the Council will consider him qualified to coöperate with engineers in the advancement of professional knowledge. He need not be an engineer."

The committee recommends the following to be added at the end of C 11 of the constitution.

> "A person who is over 30 years of age cannot enter the Society as a Junior."

The report of the Membership Committee published in The Journal for December 1908 gives in full the reasons for desiring the change. The proposed amendments were discussed, and, in accordance with the rules governing the amendments to the constitution, will be presented at the annual meeting for final action, after which they will be sent to the membership for letter ballot.

Prof. Ira H. Woolson, who was a member of the Membership Committee for five years, heartily commended the proposed change and hoped it would become a part of the constitution.

Prof. F. R. Hutton proposed an amendment to C 45, adding "Public Relations Committee" after "House Committee."

RESOLUTION IN REGARD TO THE UNITED STATES PATENT OFFICE

In view of the fact that it has been brought to the notice of the Society that a movement is under consideration to increase and improve the facilities for the work of the United States Patent Office, Prof. F. R. Hutton introduced the following resolution.

Resolved, That this Society in convention assembled requests the Council of the Society to consider the desirability of taking some action in furtherance of the movement to increase the Patent Office facilities, and, if deemed advisable, that they request the individual members to take steps to urge their influence to this end upon their Senators and Representatives.

The resolution was voted by the meeting.

PROFESSIONAL SESSION, WEDNESDAY MORNING

Four papers were presented at this morning session, two of which related to the conveying of materials. The first was upon A Unique Belt Conveyor, by Ellis C. Soper, of Detroit, Mich., which described an installation consisting of a conveyor one-quarter mile long, so located on an incline that less power is required to operate it empty than when loaded. Data upon performance were given. The second was upon Automatic Feeders for Handling Material in Bulk by C. Kemble Baldwin, of Chicago, Ill. This contained outline drawings and descriptive matter upon different designs of feeders, to enable the engineer to select the type best suited to his needs.

These two papers were discussed by: William T. Donnelly, William A. Bole, T. A. Bennett, Harrington Emerson, Fred J. Miller, Geo. Dinkel, W. E. Snyder, E. J. Baufield.

The third paper was upon A New Transmission Dynamometer, by Prof. Wm. H. Kenerson of Providence, R. I. This is made in the form of a shaft coupling. The apparatus contains an oil chamber, one side of which is a diaphragm, and it is so arranged that pressure is brought against this diaphragm directly proportional to the amount of power transmitted. A gage or other registering apparatus is connected with the oil chamber by a small tube which indicates the pressure and the water power transmitted. Discussion was offered by A. F. Masury.

The last paper was upon Polishing Metals for Examination with the Microscope by Albert Kingsbury, Pittsburg, Pa., in which he described the use of a polishing machine carrying discs faced with common paraffin and charged with wet abrasives. This produces excellent surfaces on all the harder metals and alloys, but has not proved serviceable upon the soft metals, such as lead.

WEDNESDAY EVENING LECTURE

On Wednesday evening Frederick H. Newell, director of the Reclamation Service, was to have lectured on Home Making in the Arid Regions. As he could not be present a lecture on this subject was given instead by Arthur P. Davis, Chief-Engineer of the Reclamation Service.

The United States Reclamation Service in its seven years of existence has undertaken 26 projects situated in 16 different states and territories of the West. It has invested in construction about $40,000,000. Nineteen projects have been brought to a point where some land is now under irrigation. Water is ready for delivery to about half a million acres. An average of about 10,000 laborers is employed on this work, and over 55,000,000 cu. yd. of rock and earth have been excavated. Over 2000 miles of canals have been built and 56 tunnels have been bored, which have a total length of over 13 miles.

Twelve large earthern dams, and one high masonry dam have been completed, and two other masonry dams, which will rank among the highest dams in the world are in an advanced stage of construction. Many of these projects are in remote localities into which roads had to be built, some of which were carved in precipitous rock, or tunnelled through mountains. In the aggregate 342 miles of roads and 793 bridges have been constructed.

In some localities, especially on the Pacific slope, the mild climate, and the nearly perpetual sunshine, produce remarkable results in the growth of fruits, which for color, flavor and physical perfection cannot be equaled in a more humid climate. The chemical force in sunshine and a perfectly regulated water supply are also evident in the yields of vegetables and forage crops.

The lecture was illustrated by many beautiful slides.

Gas Power Section

At this session, F. R. Low, Chairman of the Gas Power Section presided, and Geo. A. Orrok acted as Secretary. Previous to the reading of the professional papers were reports from the committees.

Membership Committee: The report showed a total membership of 302, of which 177 were members of The American Society of Mechanical Engineers and 125 were affiliates. The Membership Committee is thoroughly organized with representatives in different cities.

Literature Committee: Prof. C. H. Benjamin gave a verbal report of this committee stating that the committee is organized for work and had laid out a tentative program. It was hoped to index the books on the subject of gas power and articles in periodicals dealing with gas power and allied subjects; also to present reviews of new books and abstracts of important articles. There would be two fields for work: one, a prominent one, and the other in the line of current work relating to popular reviews and abstracts for the benefit of members.

PLANT OPERATIONS COMMITTEE: A verbal report was offered by Irving E. Moultrop reporting progress and that standard forms for obtaining operating data on gas power plants were in preparation. The committee has a large membership and is widely scattered so that it had been impossible to arrange a meeting, but the work had been advanced as far as possible by correspondence.

Reports of other committees will be offered later.

Mr. Orrok stated with reference to the work of committees that it is conducted with the idea that as the Gas Power Section has been formed while the art is young it will be possible to place a record of its development on file to keep at the headquarters of the Society. Such data in connection with the large library will place at the disposal of anyone interested in the industry the available information upon the subject of gas power.

Following the presentation of the reports came the professional papers, the first of which was on Marine Producer Gas Power, by C. L. Straub of New York. This paper explained the conditions opposing the earlier adoption of producer gas power for marine service and gave a summary of marine gas power plants in operation at present. It compared the updraft and downdraft of producer gas apparatus and contained comparative drawings of the steam equipment and two types of producer gas equipment for a 306 ft. boat. Discussion was offered by the following: J. A. Holmes, George Dinkel, Henry Penton, Irving E. Moultrop, Herbert M. Wilson, E. T. Adams.

The next paper was upon The Operation of a Small Producer Gas Power Plant, by C. W. Obert of New York. It presented a general description of a producer gas power plant in the Westchester market building of Swift & Company, Bronx Borough, New York. The author outlined the operating and maintenance system developed for keeping producers and engines in proper condition for continuous operation. This paper was discussed by: J. A. Holmes, John H. Norris, Wm. A. Bole, Henry R. Cobleigh.

A paper was presented upon A Method of Improving the Efficiency of Gas Engines, by Thomas E. Butterfield of Philadelphia, Pa. It related to the securing of higher efficiency by reducing the clearance and increasing the compression and referred especially to a method of diluting with an inert gas the charge drawn in during the suction stroke of an Otto cycle engine. By this means premature ignition and other troubles incident to high compression are avoided. Discussion followed by A. M. Greene, Jr., and W. O. Barnes.

The last paper of the session was upon Offsetting Cylinders in Single-Acting Engines by Prof. T. M. Phetteplace of Providence, R. I. It gave the results of an investigation of this subject in which the various factors entering into the problem were taken into account. Discussion was contributed by Winslow H. Herschel and John H. Norris.

Presentation of Portrait of Rear-Admiral Melville

On Thursday evening was the presentation to the National Gallery of a portrait of Rear-Admiral Geo. W. Melville with addresses given in the auditorium of the New Willard. President Smith presided and a large audience assembled for the ceremony and was addressed by Rear-Admiral Melville on The Engineer in the Navy. Mr. Walter M. McFarland of Pittsburg, Pa., gave an appreciation of Melville as a man and of his work for the nation and the profession. The portrait was accepted with appropriate remarks by Dr. Chas. D. Walcott, Secretary of the Smithsonian Institution.

At the conclusion of the ceremony, President Smith appropriately asked that Mr. Sigismond de Ivanowski, the Russian artist who had produced so admirable a likeness of Melville, be escorted to the platform. This noted artist briefly and simply told of his attempt to portray the strong characteristics of his subject and displayed evident pleasure that his efforts were so warmly appreciated.

Professional Session, Friday Morning

Five papers, and a continuation of the Safety Valve discussion given at the February meeting in New York, were scheduled for this session. The first paper was upon Small Steam Turbines by Geo. A. Orrok of New York. The various types of turbines now on the market were illustrated and described and a number of steam consumption curves were given to demonstrate the economy that might be expected from machines of this type. Discussion was offered by the following: Charles B. Rearick, Charles A. Howard, Prof. R. C. Carpenter, W. D. Forbes, R. H. Rice, Harry Y. Haden, Fred. D. Herbert, W. E. Snyder. William T. Donnelly, F. H. Ball.

A paper on Compressed Air Pumping Systems of Oil Wells by Edmund M. Ivens of New Orleans, La., was read, in which a description was given of compressed air plants at Evangeline, La., oil fields, and the results of tests upon these plants with different types of apparatus. Discussion by: F. A. Halsey, Chas. E. Joubert, Sanford A. Moss, and J. E. Callan.

Following this was the Safety Valve discussion in which the following participated: F. L. Pryor, E. F. Miller, Geo. H. Musgrave, A. B. Carhart, Sidney B. Paine, M. W. Sewall, Albert C. Ashton, A. F. Nagle, Jerome J. Aull, A. J. Hewlings, F. M. Whyte, P. G. Darling.

Two papers followed upon the properties of steam; one by Prof. C. H. Peabody, of Boston, Mass., on Specific Volume of Saturated Steam, and the other upon Some Properties of Steam by Prof. R. C. H. Heck of New Brunswick, N. J. The former reviewed the results of experiments which might form the basis of a computation of specific volumes at various temperatures and compared the computed results with experimental determinations of the same quantities. The latter paper summarized the important work of Holborn and Henning and compared the results of other investigators. These two papers constituted another step ahead in the work that is now being accomplished toward securing accurate information upon the properties of both saturated and superheated steam. Discussion was offered by: Prof. Wm. D. Ennis, Sanford A. Moss.

The last paper was by H. V. Wille, Philadelphia, Pa., on A New Departure in Flexible Staybolts. This paper proposed the employment of tempered spring steel in the manufacture of the stems of staybolts, the ends being of soft steel so as to permit riveting over in the boiler. Discussion by: Wm. Elmer, W. E. Hall, Alfred Lovell.

This, the last session of the meeting, closed with the passing, unanimously, of a resolution extending the thanks of the Society to those who had afforded so abundant entertainment to their visitors. The text of the resolution is as follows:

RESOLUTION OF THANKS

Whereas The American Society of Mechanical Engineers in convention assembled at Washington, May 4–7, 1909, desires to express its appreciation of the hospitality extended to its visiting members and friends by its hosts, and to all who by untiring efforts have made the Spring Meeting of 1909 so extraordinarily pleasant and profitable an occasion,

Be it Resolved That the Secretary be instructed to extend the thanks of the Society and to express the profound appreciation of its members and guests for the hospitality extended and the entertainment afforded throughout the convention by the Washington Society of Engineers, by Mr. Walter Ashfield McFarland, Chairman of the Local Committee, by the Local Committee itself; and to the members of the Reception Committee for Tuesday evening.

Special thanks are tendered the Chairman of the Ladies' Committee, Mrs. James Loring Lusk, and the members of that Committee for their cordial entertainment of the visiting ladies, and for their share in the social events of the meeting.

The visiting members extend thanks to the President, Mr. Taft, for his reception of members and guests at the White House; to the Secretary of War, Mr. J. M. Dickinson, for the exhibition drill of troops at Fort Myer; to Mr. Davis for his lecture on Home-Making in the Arid Regions; to Rear-Admiral Melville for his address on The Engineer in the Navy; to the University Club of Washington for the use of its club rooms; to the Columbia Golf Club; and to the Western Union Telegraph Company for sending messages free of charge.

The Secretary is authorized to extend this vote of thanks to all others from whom courtesies were received, including those in charge of the public and private works which were thrown open to the members for inspection

ENTERTAINMENT

During the entire convention an information bureau was conducted at the Society headquarters by Chairman Walter A. McFarland of the Local Committee, where the various excursions were organized. These not only included trips to the public buildings, but to government institutions and other points of technical interest, among which were the Bureau of Standards, the station of the Potomac Electric Power Co., the Union Railway Terminal, the Naval Gun Factory, the District pumping stations, etc.

At the ladies' headquarters in the New Willard, tea was served each day from four to six o'clock and the visiting ladies as well as many members of the Society, accepted the hospitality extended by the ladies at this time. Sight-seeing automobile trips for the ladies were also arranged on each day, which were largely patronized and greatly enjoyed.

On Wednesday afternoon was the excursion to Fort Myer to witness the exhibition drill. A large number attended this outing and the evolutions performed by the several troops and the unusual skill of both riders and drivers and the thoroughly trained horses, called forth round after round of applause. Two battalions of artillery with guns and caissons went through evolutions of great complexity. Two troops of cavalry went through various formations, apparently equally as difficult, and a troop of bare-back riders displayed horsemanship that captivated the audience.

On Thursday afternoon the reception of members and guests by President Taft in the East room of the White House was very generally attended.

On Friday afternoon following the professional session, many went by boat to Mt. Vernon to visit the beautiful estate and home of Washington. A wreath from the Society was placed by Washington's tomb, the members grouping themselves about the entrance as this was done in recognition of the memory of the first president of our country.

It was planned to go by train from Mt. Vernon to Fort Myer to witness the ascension of the dirigible balloon located there, which had been filled and otherwise prepared for a trip to be made on this occasion. Rainy weather, however, made it impossible to give this exhibition and most of the company returned directly to the New Willard.

MEETING OF MEMBERS AND OTHER ENGINEERS IN BOSTON

A meeting was held in Boston, April 16, 1909, to discuss the advisability of holding meetings of the Society in that city. The President and the Secretary of the Society attended, and there were present about 160 members and guests. Irving E. Moultrop, Manager of the Society, was elected temporary chairman, and Ralph E. Curtis, temporary secretary of the meeting.

ADDRESS BY THE PRESIDENT

Mr. Smith made an address in which he gave assurance that the Society is deeply interested in any movement tending to bring engineers closer together for their general and individual good. He spoke of the recent action of the Council authorizing the Meetings Committee to arrange for meetings in various places upon the same basis as meetings are now held in New York, and said that it is the desire of the officers of the Society that these meetings shall be as free and open as is consistent with the traditions and high professional standards which the Society has maintained during its thirty years' experience. To that end specific rules for their government have not been laid down. The Council and Meetings Committee are disposed to meet this question in the most liberal manner.

Mr. Smith placed the emphasis on the holding of meetings of the Society in different cities rather than forming sections or branches; also on the advantage to members of presenting papers before the meetings on such a basis, and their publication in the Journal, in advance, when accepted, making it possible to have them discussed in all the cities where meetings are held. He advocated the maintenance of the solidarity of the membership of The American Society of Mechanical Engineers, rather than encouraging its division into sections. He thought Boston an ideal place in which to inaugurate this new movement, on account of the large number of members of the Society in that vicinity, there being about 335. Mr. Smith further emphasized the friendly spirit of coöperation of the Society toward other engineering societies; saying also that engineers are welcome at meetings whether or not they are members of any society. He mentioned as being held in particular esteem the Boston Society of Civil Engineers and said that The American Society of Mechanical Engineers desires to work in coöperation with that society.

ADDRESS BY THE SECRETARY

Mr. Rice said that the call for this meeting, addressed to all interested in mechanical engineering, is typical of all professional meetings of The American Society of Mechanical Engineers. Wherever a meeting of the Society is held, anyone interested in engineering is welcome. He endorsed all that President Smith had said, and added that the opportunity of coming together for an exchange of experiences and views is essential to the life and growth of any society. He said that it has become evident that two conventions a year are not sufficient for a national society and it is further evident that the holding of meetings more frequently in one place does not create a national spirit.

In regard to the formation of separate societies, the Secretary said: When the first engineering societies were formed there were not so many prominent specialties as at present, so they constituted themselves civil engineers, that is, all engineers not military. Later, when engineers began to specialize, separate societies were formed, so that we now have four large national engineering societies, and many others, national and local. He emphasized the main idea of providing meetings of the profession rather than multiplying societies. He thought that while there is still necessity for specializing, it could be obtained within the societies already formed without the duplication of organization and expense.

Mr. Rice said that the question before the meeting was, how can the engineering profession in Boston and vicinity best get together for common and individual good, and stated that The American Society of Mechanical Engineers desires to do what will best serve the profession. He expressed the hope that that would be accomplished by bringing together the various organizations in a common headquarters rather than by the formation of a new organization. One of the important advantages of such a course is economy. The Society will bear the essential costs, such as sending out notices, cost of hall, printing, stenographer, etc. In answer to a question in regard to the participation of the students, the Secretary replied: By all means include them, and make them welcome at all your meetings.

Mr. Rice quoted from Sir Thomas Telford's address, upon taking office as the first President of the Institution of Civil Engineers: "Judicious regulations are absolutely necessary to all societies, but I trust that in this the good sense of the members will always prove that manners and moral feeling are superior to written laws." He closed by declaring that coöperation and coördination should be the motto of the profession.

GENERAL DISCUSSION

Mr. Moultrop agreed with the Secretary that there are already too many societies and that it would be both better and cheaper to have local meetings of national societies. He spoke specially of the advantages of personally meeting other local engineers.

Henry Bartlett moved that the members of The American Society of Mechanical Engineers of Boston and vicinity hold local meetings and that a committee of arrangements get into communication with the Meetings Committee of the Society. The motion was seconded and passed.

Mr. Bryant, Vice-President of the Boston Society of Engineers, although he declared that he was not speaking officially, felt certain that local meetings of The American Society of Mechanical Engineers in Boston could count upon the coöperation of the Boston Society of Civil Engineers.

James D. Andrew moved that the present committee of the Boston Society of Civil Engineers, composed of Messrs. Hollis, Miller, Main, Libbey and Moultrop, being also members of The American Society of Mechanical Engineers, be appointed to conduct the proposed meetings. The motion was unanimously adopted.

Fred R. Low, Chairman of the Gas Power Section, spoke favoring the scheme of monthly meetings as being freer in discussion and affording an opportunity for engineers to meet each other personally.

Paul Winsor, Superintendent of Motive Power and Machinery of the Boston Elevated Railroad, expressed his interest in the formation of an organization in Boston.

Prof. W. W. Bird said that the Worcester Polytechnic would do everything possible to help local meetings in Boston.

Prof. Geo. F. Swain expressed his pleasure in the plan of holding meetings in Boston as a means of improving the standing of the profession and of making the profession a force in the community.

Prof. L. S. Marks thought there could be no doubt about the desirability of having local meetings, and heartily approved of the broad lines on which the organization is being formed, which welcomes engineers of all grades of experience. He said that the students would be greatly stimulated by the opportunities, and their interest and enthusiasm may help the older members.

Prof. D. C. Jackson said he was certain, from his experience in the Western Society of Engineers in Chicago, that meetings of a national society only strengthen the local societies.

Prof. Gardner C. Anthony said he would welcome most heartily any such organization as this, as a means of promoting the personal acquaintance of members. He also spoke of the influence of students and the desirability of interesting them while they are in college. He said that Tufts College would coöperate to promote the interests of the Society wherever possible.

Francis W. Dean suggested that members in Boston would have to write papers, in order to keep the meetings alive.

E. G. Bailey spoke in favor of securing practical papers, as opposed to theoretical, and favored the scrutiny of the papers to be presented, by some committee capable of deciding what would be interesting to members in Boston.

Professor Lanza spoke briefly saying that there are enough mechanical engineers in Boston to keep the meetings alive if they keep the proper stimulus. He thought there would be no interference between the Boston Society of Civil Engineers and the meetings of The American Society of Mechanical Engineers.

COMMUNICATION FROM THE CHAIRMAN OF THE MEETINGS COMMITTEE

The attention of the members of the Society is especially called to a resolution that was recently passed by the Meetings Committee and approved, with slight modifications, by the Council, as follows:

> *Resolved:* That the Meetings Committee may, subject to the approval of the Council, arrange, authorize and discontinue, as in the judgment of the Meetings Committee may be for the best interests of the Society, with members of the Society residing in places other than New York, for the holding of meetings in such places, as is now done monthly in New York, for the presentation and discussion of such papers as may have been previously accepted by the Meetings Committee. The proceedings of such meetings to be reported stenographically, transcribed and sent promptly to the Meetings Committee. The expenses of such meetings to be defrayed by the Society on a basis prearranged with the Meetings Committee; such expenses to be under the control of the Executive Committee of the Council for approval in general, before such expenses are incurred.

The monthly meetings of the Society that have, for the past few years, been held in New York, have been very successful. They are usually informal and there is sufficient time to permit of a thorough discussion of the papers submitted by the members present. This feature has been so pronounced that the Meetings Committee has recognized the desirability, for this and other reasons, of reducing the number of papers assigned to the professioual sessions at the Spring and Annual Meetings to permit of their more thorough discussion.

Previous to the adoption of the above resolution, monthly meetings of the Society at the headquarters in New York were the only ones authorized by the Council. But with an association extending over so large a geographical area as that covered by The American Society of Mechanical Engineers, the accessibility, and therefore the attendance at the meetings, has been practically restricted to those members residing in or adjacent to New York, which area contains less than 23 per cent of the total membership of the Society.

It was, therefore, with the object of extending this privilege, in so far as the funds of the Society will permit, that the aforesaid resolution of the Meetings Committee was presented.

The resolution carries with it the distinct understanding that such meetings, wheresoever held, are meetings of the Society and not of branches nor sections. They are to be conducted under the same privileges and restrictions, no more and no less, than those governing the meetings held in New York. It is not essential that such meetings be held monthly. The number of meetings to be held during a season would depend on local conditions, and to this end the Council and Meetings Committee would be more or less guided by the recommendation of the local members.

The sentiment that prompted the resolution was that geographical location of membership was a mere incident, and in view of the success of the monthly meetings held in New York there is no reason why the same opportunity should not be extended to all localities where the number of members adjacent thereto would warrant. With the object of meeting any and all local conditions that may arise, the resolution was made broad and liberal.

By reference to the Constitution and By-Laws of the Society it will be seen that the restrictions placed upon the conduct of such meetings as are covered by the resolution are exactly the same as those governing all meetings of the Society. These rules of procedure are the outgrowth of many years of experience, and are only such as have been found necessary to safeguard the high professional standing and traditions of the Society. Their enforcement is under the guidance of officers selected from and representing the Society at large.

From the scope of the resolution it will, therefore, be seen that the opportunity to hold meetings in any locality is extended to the members therein, but that it is not intended that such meetings must necessarily be held monthly; nor even simultaneously with those held in New York; nor that the same papers be necessarily discussed at all the meetings. No further organization is required than a Chairman and Secretary selected from among the local members. They will request the Meetings Committee of the Society to hold meetings, stating at the time the number of meetings that it is considered can be advantageously held during a season, and give an estimate of the cost of such meetings. The movement is not intended to conflict with any local engineering association that may exist, but, on the contrary, to coöperate with such organization by extending invitations to its members to attend the meetings of the Society, and in any other way consistent with the rules of the Society. No doubt cases will arise, when the Meetings Committee will be ready to delegate to two or more local members authority to act relative to the acceptance of papers submitted for presentation at the meeting.

It is the desire and wish of the officers and the Meetings Committee to assist the members of any locality in the organization and conduct of any meetings they may wish to hold. To this end, any members desiring meetings should unhesitatingly communicate with the Secretary relative to any doubtful features that may have arisen.

The movement inaugurated by the resolution should be of great benefit to the members. It should bring out much excellent material that is now dormant and add much valuable discussion, the best of our contributions, for use in The Journal and the Transactions. It permits the simultaneous consideration of the same paper at two or more points, and doubtless there would be occasions when the Meetings Committee would wish to have simultaneous discussion of papers that may have been arranged to be presented at some other meeting place.

It is believed that the spirit of the resolution carried out in its entirety will bring the members more closely together, both professionally and socially, than any movement that has ever been inaugurated, and in that way give the Society an impetus for much and lasting good.

REPORT OF ADVISORY COMMITTEE ON FUELS AND STRUCTURAL MATERIALS

The representatives of the Society on the Government Advisory Board on Fuels and Structural Materials presented a report to the Council at its meeting, May 4, concerning the work of the board. An abstract is here given and the complete report is on file in the Secretary's office, where it may be consulted.

ABSTRACT

Congress made provision in 1905 "for analyzing and testing at the Louisiana Purchase Exposition the coals and lignites of the United States, in order to determine their fuel value and the most economic methods for their utilization for different purposes, under the supervision of the Director of the U. S. Geological Survey." For this work $60,000 was appropriated.

It was provided that all testing machinery and all coals and lignites tested should be contributed without charge to the Government. The Director of the Survey appointed a committee of three from his staff to have charge of the work, and they, in turn, appointed experts, in several cases members of The American Society of Mechanical Engineers, each one of whom was given charge of some specific phase of the whole work.

The conditions incident to a great exposition were not favorable for scientific work, but the value of the results accomplished is indicated by the reports issued upon field work, the classification of coals, chemical analysis of fuels, and investigations concerning producer gas, coking, briquetting and the washing of fuels.

Later, Congress made appropriations for continuing the work another year. At this time the President of the United States requested a number of civilian engineers, representing prominent societies, among which was The American Society of Mechanical Engineers, to form a board to assist the Government in an advisory capacity in the work of testing fuels and structural materials.

Organization was effected at the first meeting of the advisory board and there have been two subsequent meetings, one at James-

town in 1907, and the other in Pillsbury in 1908. Committees of the full board have held meetings at various times for the discussion of special problems. In all that has been done, the representatives of The American Society of Mechanical Engineers have had their full share.

For the fiscal years ending June, 1907 and 1908, Congress made specific appropriations for testing fuels and for testing structural materials. For 1908 the sum of $250,000 was appropriated for fuels and $100,000 for structural materials. For the year ending June 1909, a smaller appropriation was made for fuels and structural materials and one of $125,000 was added for investigations of mine explosions. The work in testing structural materials has been differentiated. In the fuel investigations coals from hundreds of mines have been analyzed, subjected to calorimeter tests, tested under boilers, tested in gas producers, and sometimes tested to determine their coking properties.

A study of mine wastes and of problems involved in the utilization of inferior grades of coal has been going on continuously, and the value of the briquetting process as applied to the lignite beds and to the fine coals and older coal fields has received due attention. Attention is now being given to the fundamental problem of combustion, to the study of flameways, and to the temperature and composition of gases therein, and to the effect of baffling upon the room required by flames for satisfactory combustion; all as developed from typical fuels. The investigations concerning mine explosions have been demonstrative rather than investigational and have been of great importance. As a result of work along these several lines, 30 articles have been published or are being prepared. Laboratories have been established at Pittsburg which promise to be permanent. A bill is now before Congress authorizing the establishment of a Bureau of Mines which is designed to give the work of testing fuels and structural materials a more substantial organic setting and to insure it permanent means of support.

MEETING OF THE COUNCIL

At the meeting of the Council, May 4, 1909, there were present Messrs. Bond, Gantt, Hunt, Hutton, Miller, Smith, Swasey, Wiley, the Secretary and J. W. Lieb, Chairman of the Library Committee.

The appointment of the Nominating Committee was announced: Worcester R. Warner, Cleveland, *Chairman;* Walter M. McFarland, Pittsburg; Morgan Brooks, Urbana, Ill.; David Townsend, Philadelphia; Francis W. Dean, Boston.

The appointment of the Committee on Power Tests was announced: Edward T. Adams, Geo. H. Barrus, L. P. Breckenridge, D. S. Jacobus, William Kent, Chas. E. Lucke, Edw. F. Miller, Arthur West, Albert C. Wood.

Voted: To receive and place on file the report to the Council by W. F. M. Goss, George H. Barrus and P. W. Gates, members of the Government Advisory Board on Fuels and Structural Materials, U. S. Geological Survey.

Voted: To print an abstract in The Journal and to state in the abstract, that the full report is on file in the office of the Secretary for consultation by the membership.

Voted: To approve the report of April 13 of the Executive Committee, acting as a Committee on Standards.

The Meetings Committee reported that a meeting of mechanical engineers residing near Boston was held April 13, and a similar meeting of the members in St. Louis, April 10. The President and the Secretary addressed the meeting in Boston.

The committee of arrangements appointed by the Boston Society of Civil Engineers, who are also members of this Society, is as follows: Ira N. Hollis, *Chairman;* Joseph H. Libbey, Charles T. Main, Edward F. Miller, Irving E. Moultrop. These gentlemen were again appointed by the meeting itself as a committee of arrangements for future meetings of the Society in Boston.

The Library Committee reported that they had received the action of the Board of Trustees of the United Engineering Society, on the report of the Joint Library Conference Committee, covering the future policy of the Library with respect to:

a Gifts intended for the Library in its broad and general sense, as distinguished from gifts to the Library of one of the Founder Societies.
b An associate society which may desire to have its library in whole or in part placed in the Library for public use, under the general control of the Library administration as a whole.
c Re-arrangement of the libraries of the three Founder Societies to bring them under one numerical arrangement.
d The formation of a United Engineering Society Library.

With respect to the foregoing items the Committee recommends as follows:

a, b That we receive the libraries of associate societies, provided the books are permanently left with the Library.
c That the libraries of the three founder societies be adjusted to bring them under one numerical arrangement.
d That the United Engineering Society Library be instituted, in which this Society shall have joint ownership with the other Founder Societies.

Voted: To approve the recommendations of the Library Committee.

Voted: To authorize the Library Committee to solicit donations for the above library.

Voted: That as a general policy library privileges be exchanged with sister societies and similar institutions; and it was specifically

Voted: To exchange library privileges with Columbia University in response to their request and the recommendation of the Library Committee of the Society.

Voted: That the list of all accessions to the libraries of each of the Founder Societies and of the United Engineering Society be published regularly in The Journal.

The report of the Publication Committee was received and the Secretary directed to advise that committee of the previous action of the Council with respect to the disposition of the income derived from advertising.

The report of the House Committee was received, stating that they had let the contract for partitions and sliding doors, and for the tinting of walls and rugs for three rooms, and for furniture for the hall.

The Council approved the action of the Finance Committee agreeing to an appropriation of $500 for increase of membership, the expenditure to be deferred until later in the fiscal year.

The Secretary read communications from the Chairman of the United States Delegation to the Pan-American Scientific Congress in which it was voted that the delegation officially bring to the attention of the learned societies of national scope in the United States the desirability of inviting the scholars and investigators of Latin America to coöperate with them.

Voted: To refer the above matter to Messrs. Hunt, Hutton and Miller for consideration and report.

GENERAL NOTES

MEETING OF THE SOCIETY IN BOSTON, JUNE 11

A meeting of the Society will be held in Boston, June 11, at 8 p. m., in the Lowell Building of the Massachusetts Institute of Technology.

The meeting is called for the reading and discussion of the paper on Small Steam Turbines, presented by Geo. A. Orrok at the Washington meeting. The manufacturers of small turbines have been invited to attend. The meeting is open to all interested in engineering and students are specially welcome.

This meeting is in harmony with the new policy of holding meetings of the Society in different cities, which the Chairman of the Meetings Committee, W. E. Hall, describes in this issue. The papers published in The Journal will be more widely discussed when coming up before meetings in different parts of the country and the readers of The Journal at large will receive the benefit.

THE STEVENS INSTITUTE BRANCH

The Stevens Engineering Society, affiliated with The American Society of Mechanical Engineers, listened to an account of extensive visits to various automobile factories, from Prof. F. De R. Furman, Professor of Kinetics and Machine Design, on March 4. A week later, Prof. L. A. Martin, head of the Mechanics Department gave a lecture on Centripetal and Centrifugal Force. He dwelt particularly on D'Alembert's principle and its applications, and explained the need for flexible shafts in high-speed turbines. On March 18 a lecture on Conservation was delivered by H. S. Putnam, who, was one of the speakers at the National Conference of Governors. The subject of Aëronautics has been taken up by the Branch, and on March 23, Messrs. Armstrong, '09, and Upson, '10, told of their experiments with aëroplanes. The Branch visited the Morris Park racetrack to witness some demonstrations of flight by M. Triaca, of the New York Aëronautic Society. Several new members have been received.

A lecture on Wireless Telegraphy was given by Fred. K. Vreeland, of the Electrical Testing Laboratories, New York, on April 15. He explained the elementary principles of wireless telegraphy, and made some interesting experiments.

Dr. Geo. V. Wendell, of the Institute, delivered a lecture, April 22, on Radiation and Optical Pyrometry, in which he, explained the "black body," and the different classes into which ether-vibrations are divided. An inspection trip was made to plants in Newark. The following officers for the year were elected: H. H. Haynes, President, J. S. Ware, Vice-President; R. H. Upson, Secretary; E. T. P. Greenidge, Treasurer.

STUDENT BRANCH AT LELAND STANFORD

The mechanical engineering students of Leland Stanford University have organized a student branch of The American Society of Mechanical Engineers under the name of the Stanford Mechanical Engineering Association. Its object is to further an interest in professional work and to promote good fellowship among its members.

The branch has organized with three classes of members, active, associate, and honorary. Active members may consist of juniors, seniors, graduates and others. Juniors, seniors and graduate students may be elected to membership by a $\frac{2}{3}$ vote of the association; sophomores may be elected by unanimous vote of the active membership. Honorary and associate members are exempt from dues. The student officers shall consist of a chairman, a vice-chairman and a secretary-treasurer. The honorary chairman shall be ex-officio a member of the governing committee.

The Section has elected Professor W. F. Durand, Mem. Am. Soc. M. E., Honorary Chairman, P. H. Van Elton, Chairman, A. C. Coonvadt, Vice-Chairman, and Henry L. Hess, Secretary and Treasurer.

ACTIVITIES OF THE STUDENT BRANCH AT PURDUE UNIVERSITY

The Mechanical Engineering Society of Purdue University, affiliated with The American Society of Mechanical Engineers, held a meeting at the University, Lafayette, Ind., April 14. The meeting was addressed by L. V. Ludy, Mem. Am. Soc. M. E., Professor of Mechanical Engineering of the University. The subject of his address was Laboratory Tests of Automobiles.

At the meeting of the Branch April 26, Theodore Weinshank, Mem. Am. Soc. M. E., of Indianapolis, delivered a lecture on the

Heating of Feed Water for Boiler Purposes. It was illustrated by lantern slides, showing various heaters and purifiers.

THE PURDUE UNIVERSITY BRANCH

The Purdue Mechanical Engineering Society, affiliated with The American Society of Mechanical Engineers, held the final meeting of the year on May 5, at which the following officers were elected for the first semester of next year: E. T. Kirk, President; T. J. Kelley, Vice-President; W. P. Dornes, Recording Secretary; J. R. Jackson, Corresponding Secretary; Members of the Governing Board: L. V. Ludy, Honorary Chairman, C. O. Witt, C. O. Luhn.

UNION CATALOGUE FOR THE LIBRARY

The work of making a union catalogue of the books in the three libraries comprising the Library of the Engineering Societies was begun September 1, 1908. A card catalogue of subjects was completed early in May and the card catalogue of authors will soon be finished. By this combined catalogue, which is placed in a handsome cabinet recently purchased by the Library Committee, the resources of the Library will be made much more readily available to patrons.

In addition to this catalogue, an index to the contents of all current technical publications in the library will be kept on file. The trade catalogues have also been indexed by subjects and firms. The catalogues are kept in a vertical file attached to the cataloging cabinet, and are readily accessible to all persons using the library.

Another convenience recently added to the library is an alphabetical list, which has been printed and framed, of all current periodicals on the shelves.

HONORARY VICE-PRESIDENTS OF THE SOCIETY

The President, Jesse M. Smith, of New York, will represent the Society at the commencement exercises at Columbia University.

Worcester R. Warner, Mem. Am. Soc. M. E., and Calvin W. Rice, Secretary Am. Soc. M. E., are appointed honorary vice-presidents to represent the Society at the inauguration of Richard Cockburn Maclaurin, M.A., LL.D., Sc.D., as President of the Massachusetts Institute of Technology.

ARTICLE ON THE PANAMA CANAL BY PAST-PRESIDENT JOHN R. FREEMAN

John R. Freeman, Past-President, Am. Soc. M. E., who accompanied Mr. Taft to Panama as one of the board of advisory engineers appointed by President Roosevelt, has contributed an article to the *Outlook* (April 24) on The Problem of the Panama Canal. An editorial in the *Outlook* of this issue says of Mr. Freeman:

> Mr. John R. Freeman is one of the most distinguished of contemporary hydraulic engineers. He is a graduate of the Massachusetts Institute of Technology, and has been engaged in many great water-power enterprises, both private and public. He has been a consulting engineer to the Panama Canal Commission and to the Board of Water Supply which is building the great Catskill Aqueduct. The opinion of no engineer in this country will be treated with greater respect on the question of canal locks and dams, by professional colleagues, than that of Mr. Freeman. He was one of the special board appointed by Mr. Roosevelt last winter to visit Panama and report on the stability of the Gatun Dam.

TECHNOLOGY DINNER TO PROFESSOR SWAIN

Former students of the Massachusetts Institute of Technology joined in a complimentary dinner to Professor George F. Swain, Mem. Am. Soc. M. E., at Boston, on the evening of April 30. Professor Swain, who leaves the Institute shortly to become Professor of Civil Engineering at the new Graduate School of Applied Science at Harvard University, has been on the faculty of the Institute continuously for 28 years, beginning in 1881 as instructor. In that time he has earned, to an unusual degree, the esteem and affection of all who studied under him, and the dinner was an expression of this appreciation. Some seventy-five men gathered around the tables.

Addresses by prominent graduates of the Institute told of the sentiments of Professor Swain's fellow-students and pupils toward him. The speakers included: the toastmaster, J. Waldo Smith, Mem. Am. Soc. M. E.; Charles A. Stone; Prof. Alfred E. Burton; Chas. T. Main, Mem. Am. Soc. M. E.; Geo. W. Kittredge; Prof. Wm. Z. Ripley of Harvard University; Prof. Chas. M. Spofford, who is to succeed Professor Swain at the Institute; Frank L. Locke; and Professor Swain.

UNIVERSITY OF UTAH

The State School of Mines at the University of Utah has installed a road-testing laboratory as a part of the regular testing laboratory in the department of mechanical engineering. The latest bulletin from the school, which was prepared by E. H. Beckstrand, Professor of Mechanical Engineering, Mem. Am. Soc. M. E. and member of the American Society for Testing Materials, states that a series of tests were made on macadam rock found near Salt Lake City to determine its value for road-making. Samples from twenty-seven different quarries were tested for coefficiency of wear, for toughness, for recementing, value of rock dust and weathering. Limestones, granites and several other kinds of rock were among the materials tested, The Bulletin published by the University gives the results of these tests.

NORTHWESTERN UNIVERSITY ENGINEERING BUILDING

The new Swift Hall of Engineering of the Northwestern University, Evanston, Ill., was formally dedicated, May 7, in the presence of a large number of distinguished engineers. Following the introductory remarks of Pres. Abram W. Harris, an address on The New College of Engineering, an Opportunity, was delivered by John Fillmore Hayford, Director of the College of Engineering. The Need for a Broader and More Thorough Training for Engineers was the subject of the dedicatory address, which was delivered by Charles Whiting Baker, Mem. Am. Soc. M. E.

THE ADELSKJOLD MEDAL CONFERRED ON THOMAS A. EDISON

The Adelskjold medal, awarded by tbe Kungliga Vetenskaps Akademien (Royal Academy of Sciences of Sweden) has been conferred upon Thomas A. Edison, Hon. Mem. Am. Soc. M. E., "for valuable work and discoveries in useful sciences."

Mr. Edison is the first recipient of this medal, which was established from a fund donated by the late Major Adelskjold, who, previous to his death about two years ago, was a prominent member of the "department of roads and water structures" of Sweden and was associated with important railroad enterprises.

OTHER SOCIETIES

NEW YORK ELECTRICAL SOCIETY

A meeting of the New York Electrical Society was held April 21 in New York, at which A. C. Eastwood lectured on Some Labor-Saving Uses of Electric Power in the Manufacture of Iron and Steel. The lecturer gave particular attention to the economy and increase of output attending the substitution of electricity for steam in the operation of steel mills and described numerous devices recently developed for use in refining and finishing processes.

TECHNICAL SOCIETY OF BROOKLYN

At the April 16 meeting of the Technical Society of Brooklyn, in Arion Hall, Dr. L. H. Friedburg, of the College of the City of New York, presented a paper on Photography in Colors. The speaker demonstrated the different experiments and results achieved in this field from the time of Sennebier in 1775 to Joly and Lumiere of the present time, showing beautiful reproductions of color-effects in flowers, fruits and other objects.

WIRELESS INSTITUTE

The second regular meeting of the Wireless Institute was held in the Engineering Societies Building, New York, April 7, 1909. Robert H. Marriott, President of the Institute, presented a paper in which he set forth the formation, object and history of the organization. The paper also included a list of subjects on which valuable papers could be written. Ralph W. Pope, Secretary of the American Institute of Electrical Engineers, also addressed the meeting.

MISSOURI ELECTRIC, GAS, STREET RAILWAY AND WATERWORKS ASSOCIATION

The annual convention of the Missouri Electric Light, Gas and Street Railway Association was held April 15, 16, and 17, at the Colonial Hotel, Springfield, Mo. The address of welcome was read by Mayor Ernst of Springfield. Several papers were presented for discussion.

Officers were elected, as follows: President, W. A. Bixby; First Vice-President, R. J. Irvine; Second Vice-President, F. E. Murray; Third Vice-President, P. A. Bertrand; Secretary and Treasurer, C. L. Clary. The constitution was amended, changing the name of the association to the Missouri Electric, Gas, Street Railway and Waterworks Association. The next meeting will be held in Jefferson City, April 14–16, 1910.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

The annual meeting of the National Association of Cotton Manufacturers was held in Mechanics' Fair Building, Boston, Mass., April 28 and 29. Among the papers were the following: Improvements in Lighting Large Textile Areas with High Efficiency Units, A. Thatcher Holbrook; Transportation for Mill Yards, Day Baker; The Care of Commutators, T. E. Chappel.

The following officers were elected: President, Charles T. Plunkett, Mem. Am. Soc. M. E.; Vice-Presidents, G. Otis Draper, Franklin W. Hobbs; Directors for three years, George P. Grant, Jr., Edwin Farnham Greene and David S. Johnson. C. J. H. Woodbury, Mem. Am. Soc. M. E., was reëlected Secretary and Treasurer.

NEW ENGLAND RAILROAD CLUB

The regular meeting of the New England Railroad Club was held May 11 at Hotel Somerset, Boston, Mass. Charles J. Glidden gave an illustrated travelogue on The World and its People as Seen from a Motor Car, with stereopticon views. The lecture was preceded by a brief paper, with views, on The A B C of Ballooning. Mr. Glidden is an international balloon pilot, holding pilot certificates for America and France.

PROVIDENCE ASSOCIATION OF MECHANICAL ENGINEERS

On Tuesday evening, April 27, J. Ansel Brooks, Jun. Am. Soc M. E., Assistant Professor of Mechanics in Brown University, delivered the monthly lecture before the Providence Association of Mechanical Engineers on the subject of Aerial Navigation. The speaker confined most of his remarks to aeroplanes. Recent formulae giving the relation between the center of gravity and the center of pressure were discussed. The paper was followed by a smoker and general discussion, and a business meeting.

The subject of the lecture of May 25 in Alfredian Hall, was Gauges and Indicators.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS

The fifth congress of the International Association for Testing Materials will be held in Copenhagen, September 7-11. A large number of papers will be read and discussed, and arrangements are being made for visits and excursions to places of interest.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS

On April 14 and 15 the American Society of Engineering Contractors held a meeting in the Engineering Societies Building, New York. A constitution was adopted and officers and directors elected. The object of the society is the advancement of engineering knowledge and contracting practice, the maintenance of a high professional standard among its members, and the elimination of those practices and abuses that now exist in the engineering and contracting business; and to strengthen the bond between engineers and contractors. Officers for the first year were elected as follows: President, George W. Jackson, Chicago, Ill.; First Vice-President, Halbert P. Gillette, New York; Second Vice-President, F. Baxter, New York; temporary Secretary, Daniel J. Bauer, New York. The society will begin holding monthly meetings in the fall.

INTERNATIONAL CONGRESS OF REFRIGERATING INDUSTRIES

The American Committee of the First International Congress of Refrigerating Industries held a meeting May 20, with morning and afternoon sessions, in the Engineering Societies Building, New York. The object of the meeting was to hear the final report on the work of the American Committee and also to consider the matter of organizing a permanent national committee or association to affiliate with the International Association, to assist in the work of that Association and arrange for American participation in the Vienna Congress of 1910.

In accordance with resolutions passed at the Paris Congress, a permanent International Association of Refrigeration was organized at an International Conference held in Paris, January 25 last, at which meeting the United States was represented by Consul-General Mason.

Four important International Commissions were organized under the auspices of the International Association to institute researches as to the best solution of scientific, technical and industrial questions pertaining to the field of refrigeration and to seek the best administrative measures concerning the transportation of perishable products; also to undertake experiments or tests of general or international interest. The United States is asked to coöperate in this work.

AMERICAN ELECTROCHEMICAL SOCIETY

A general meeting of the American Electrochemical Society was held at the Hotel Clifton, Niagara Falls, Canada, May 6, 7 and 8. The address of the retiring president, E. G. Acheson, was delivered on Thursday evening, the subject being The Electrochemist and the Conservation of our Natural Resources.

Several papers were presented and the following officers elected: President, L. H. Baekeland; Vice-Presidents, F. J. Tone, Carl Hering, W. D. Bancroft; Managers, E. R. Taylor, W. L. Miller, W. H. Walker; Treasurer, P. G. Salom; Secretary, J. W. Richards.

AMERICAN SOCIETY OF SWEDISH ENGINEERS

A meeting of the American Society of Swedish Engineers was held in Brooklyn, N. Y., on the evening of May 1. A paper was presented by William K. Austin upon A Rotary Compounding Engine. This was illustrated by drawings and by a small engine with 4½-in. bore.

WESTERN SOCIETY OF ENGINEERS PETITION FOR SCHOOL OF MINES AT THE STATE UNIVERSITY OF ILLINOIS

The Western Society of Engineers, through its President, Andrews Allen, has appointed the following committee to draft a memorial for presentation to the Legislature of Illinois, petitioning for the establishment of a Department of Mines at the State University: A. Bement, Mem. Am. Soc. M. E., Chairman, F. A. Delano, Bion J. Arnold, John M. Ewen, Mem. Am. Soc. M. E., Isham Randolph, and Captain R. W. Hunt, Mem. Am. Soc. M. E. The Western Society of Engineers believes that in the interests of the people of the state in general, as well as those engaged in mining business, there should be established a department of the University that will tend to develop a higher degree of skill in the conduct of the mining industry.

PERSONALS

Capt. Henry A. Allen, Mem. Am. Soc. M. E., has been appointed engineer of the Illinois division of the National Guard, and will be a member of the Governor's staff with the rank of lieutenant-colonel.

Carl Angstrom, Mem. Am. Soc. M. E., formerly Managing Director of Motala Works, Motala, Sweden, has opened an office as Consulting Engineer at Stockholm, O., Sweden.

Abram T. Baldwin, Mem. Am. Soc. M. E., has been transferred from the Syracuse, N. Y., office of the Solvay Process Co., to the Detroit, Mich., office.

F. W. Ballard, Mem. Am. Soc. M. E., presented a paper on Power Costs for Factories, at the April 13 meeting of the Cleveland Engineering Society.

Wm. O. Barnes, Mem. Am. Soc. M. E., has accepted a position as Assistant Superintendent with the Miller Lock Co., Frankford, Pa.

Clay Belsley, Mem. Am. Soc. M. E., has been appointed City Engineer of Peoria, Ill.

Prof. C. H. Benjamin, Mem. Am. Soc. M. E., is co-author with Prof. G. A. Young, Mem. Am. Soc. M. E., of a contribution upon A Series of Tests on a White Steam Car, published in the May 13 issue of *The American Machinist.*

Grant D. Bradshaw, Jun. Am. Soc. M. E., has been appointed Foreman of the Billet Mill, Gary Works, of the Illinois Steel Co., Gary, Ind. He was formerly Foreman of Rod Mills, of the Joliet Plant of the company.

Prof. L. P. Breckenridge, Vice-President, Am. Soc. M. E., addressed the May 5 meeting of the Western Society of Engineers, the subject being, The Engineering Experiment Station at the State University and its Relation to Illinois Industries.

Morgan Brooks, Mem. Am. Soc. M. E., Professor of Electrical Engineering, University of Illinois, has been granted a leave of absence for foreign travel and study during the coming academic year.

John F. Buckley, Mem. Am. Soc. M. E., has become Consulting Engineer to the General Superintendent of the St. Marys Machine Co., St. Marys, Ohio. Until recently he has been associated with the Witte Iron Works Co., Kansas City, Mo., in the capacity of Superintendent.

Dudley B. Bullard, Mem. Am. Soc. M. E., delivered an address before the Society of Mechanical Foremen of Bridgeport on Modern Tools and Their Development.

An article on Heat Value of Coal from Dulong's Formula, Based on Ultimate Analysis, by N. A. Carle, Mem. Am. Soc. M. E., appeared in the May 11 issue of *Power and the Engineer.*

The Society learns with deep regret of the death of Theodore Minot Clark, fellow and member, and for four years secretary of the Boston Society of Architects.

Harold V. Coes, Jun. Am. Soc. M. E., formerly with the New York Edison Co., has accepted the position of Mechanical Engineer and Assistant to the President of the Liquid Carbonic Co., with headquarters at 67 Wells St., Chicago, Ill.

Prof. Arthur W. Cole, Jun. Am. Soc. M. E., Instructor in Mechanical Engineering, Purdue University, will go to the University of Wisconsin this summer to give a lecture course in gas and steam engines. He will also act as instructor in the laboratory. Professor Cole will return to his work at Purdue in the fall.

Charles Worthington Comstock, Mem. Am. Soc. M. E., has been appointed State Engineer of Colorado.

Barton Cruikshank, Mem. Am. Soc. M. E., formerly Designing Engineer of the Solvay Process Co., Syracuse, N. Y., has opened an office as Consulting Engineer, at Morristown, N. Y.

Carl S. Dow, Assoc. Am. Soc. M. E., has become associated with the staff of Walter B. Snow, Mem. Am. Soc. M. E. Mr. Dow was formerly Manager of Publicity, B. F. Sturtevant Co., Hyde Park, Mass.

William L. Draper, Mem. Am. Soc. M. E., formerly with the Boston, Mass., office of the General Electric Co., has retired from active work for the present.

Geo. W. Dunham, Mem. Am. Soc. M. E., formerly connected with the Olds Motor Works, Lansing, Mich., has become Chief Engineer of the Hudson Motor Car Company, Detroit, Mich.

Adolphe S. Fairbanks, Assoc. Am. Soc. M. E., has become Philadelphia Representative of the engineering department of the Vandyck-Churchill Co., with an office at 917 Arch St. Until recently, Mr. Fairbanks was associated with the Crosby Steam Gage and Valve Co., New York.

Henry A. Fergusson, Mem. Am. Soc. M. E., has severed his connection with Joseph T. Ryerson & Son, and is now District Sales Agent for the Detroit Steel Casting Co., Morava Construction Co., Steel Roof Truss Co., and H. B. Kraut Mfg. Co., with office at 514 Bank of Commerce Building, St. Louis, Mo. Mr. Fergusson is engaged also in consulting engineering work in connection with structural steel and power-plant installations.

Horatio A. Foster, Mem. Am. Soc. M. E., has been transferred from the valuation department of the Public Service Commission, District No. 1, New York, to Detroit, to take charge of the appraisal of the properties of the Detroit United Railways, for Bion J. Arnold, with whom he has been associated in the valuation of the properties of the New York City railways.

Ernest E. Gamon, Jun. Am. Soc. M. E., until recently Factory Manager of the Neptune Meter Co., Long Island City, N. Y., has opened an office in Newark, N. J., for the manufacture of water meters.

Prof. Geo. F. Gebhardt, Mem. Am. Soc. M. E., is the author of Some Live-Steam Separator Tests, published in the May 11 number of *Power and the Engineer.*

John J. Harman, Jun. Am. Soc. M. E., has become a member of the Harman Engineering Co., civil and mechanical engineers, Peoria, Ill.

A paper on The Present Value of Electrical Structural Steel, by Henry D. Hibbard, Mem. Am. Soc. M. E., presented at the May 6–8 meeting of the American Electrochemical Society at Niagara Falls.

Frank E. Herdman, Mem. Am. Soc. M. E., formerly in the service of the Enid Electric and Gas Co., Enid, Okla., as Secretary and Treasurer, has accepted a position as Manager and Engineer of the Water and Light Properties of the Village of Winnetka, Ill.

Rudolph Hering, Mem. Am. Soc. M. E., has been appointed Consulting Engineer for sewers and garbage disposal plant of San Francisco.

James H. Herron, Mem. Am. Soc. M. E., has entered the employ of the Motch & Merryweather Machinery Co., Pittsburg, Pa., in the capacity of Manager. He was formerly associated with the Detroit Steel Products Co., Detroit, Mich., as Engineer.

A biographical sketch of William Hewitt, Mem. Am. Soc. M. E., was published in the May number of *Cassier's Magazine.*

Charles A. Howard, Jun. Am. Soc. M. E., has accepted a position with the E. W. Bliss Co., Brooklyn, N. Y. Until recently he was Assistant to the Mechanical Engineer of the New York Edison Co., New York.

Joseph H. Hyde, Mem. Am. Soc. M. E., Chief Engineer of the American Car and Foundry Co., has been transferred from the St. Louis, Mo., office to Chicago, Ill.

Herman G. Jakobsson, Mem. Am. Soc. M. E., formerly with the Midvale Steel Co., Philadelphia, Pa., has been appointed Ordnance Designer of the War Department.

Frank N. Jewett, Mem. Am. Soc. M. E., who was District Manager of the Wagner Electric Mfg. Co., of St. Louis, Mo., in charge of the Chicago office, has been made Sales Manager of that company at the home office, St. Louis, Mo.

Geo. C. King, Mem. Am. Soc. M. E., has been appointed Assistant General Manager and Mechanical Engineer of the Union Irrigation Co., Washington, La. He was formerly superintendent of the Russell Engine Co., Massillon, Ohio.

Joseph P. Kirkup, Jun. Am. Soc. M. E., until recently connected with the Green Fuel Economizer Co., as Testing and Experimental Engineer, has become representative of the S. J. Wing Mfg. Co., with an office in the Philadelphia Bourse.

Francis W. Lane, Assoc. Am. Soc. M. E., for fifteen years Editor of *The Railway Age*, prior to its consolidation with *The Railroad Gazette*, has moved to Chicago, where he will act as engineering correspondent of *The London Times.*

Henry I. Lea, Assoc. Am. Soc. M. E., presented a paper on A New Method of Gas Manufacture at the March 17 meeting of the Illinois Gas Association.

Frank J. McDevitt, Jun. Am. Soc. M. E., has become Vice-President and Manager of the Ohio Steam Specialty Co., Youngstown, O. Until recently he was connectd with the Ohio Works of the Carnegie Steel Co., Youngstown, Ohio.

Emerson McMillin, Mem. Am. Soc. M. E., President of the American Light & Traction Co., New York, has been elected to the newly created position of Chairman of the Board.

Frank W. Magin, Jun. Am. Soc. M. E., recently with the Allis-Chalmers Co., Milwaukee, Wis., is now located at the New York office of the company.

Guido H. Marx, Mem. Am. Soc. M. E., Associate Professor of Machine Design in Stanford University, has been promoted to the rank of professor, the appointment to take effect next fall.

Geo. B. Massey, 2d, Jun. Am. Soc. M. E., is the author of Development of Dredges for Placer Deposits, which appeared in the April 24 number of *The Engineering and Mining Journal.*

Guy L. Meaker, Jun. Am. Soc. M. E., until recently President of The Meaker Co., Chicago, Ill., has become associated with the American Steel and Wire Co., as Assistant Superintendent of the Rockdale Works, Joliet, Ill.

Gustav A. Merkt, Assoc. Am. Soc. M. E., is the author of Analysis of Power Consumption in a Roll Pass, which was published in the April 22 issue of *The Iron Trade Review.*

Walter R. Metz, Jun. Am. Soc. M. E., has been made Superintendent of Buildings, Government Printing Office, Washington, D. C. He was formerly Leading Draftsman of the U. S. Navy Yard.

Henry C. Meyer, Jr., Mem. Am. Soc. M. E., is the author of A Central Heating and Lighting Plant for the United States Military Academy, which was published in the April 29 number of *The Electrical World.*

Dr. Richard Moldenke, Mem. Am. Soc. M. E., gave a general talk on Recent Progress in Foundry Metallurgy at the May 3 meeting of the Pittsburg Foundrymen's Association.

Herbert H. Morrison, Mem. Am. Soc. M. E., formerly of New York, has opened an office in the Syndicate Trust Building, St. Louis, Mo., as Consulting Engineer for mechanical and electrical work.

Alfred Noble, Mem. Am. Soc. M. E., and Silas H. Woodard have opened an office as civil and consulting engineers at 7 East 42d St., New York. Mr. Noble was formerly Chief Engineer, East River Div., P. T. & T. R. R., New York.

Walter A. Pearson, Mem. Am. Soc. M. E., sailed for Rio de Janeiro, May 28, to assume the position of Assistant General Manager of the Rio de Janeiro Tramway, Light and Power Co., Rio de Janeiro, Brazil. For the past few months Mr. Pearson was in the New York office of the Company.

Dwight T. Randall, Mem. Am. Soc. M. E., late engineer in charge of fuel tests, Technologic Branch, United States Geological Survey, has associated himself with the Arthur D. Little Laboratory of Engineering Chemistry of Boston, in charge of the Department of Fuel Engineering.

Train Resistance is the subject of an article contributed to the May 7 issue of *The Railroad Age Gazette*, by A. Stucki. Mem. Am. Soc. M. E.

Cecil Hamelin Taylor, Assoc. Am. Soc. M. E., who has been in the engineering department of the E. R. Thomas Motor Co., Buffalo, N. Y., has accepted a similar position with the Chalmers-Detroit Co.

Frank H. Taylor, Mem. Am. Soc. M. E., sailed May 19 for England as special representative of the Mergenthaler Linotype Co.

David Townsend, Mem. Am. Soc. M. E., read a paper before the mechanical section of the Franklin Institute, Philadelphia, Pa., on the evening of April 29, on Prevention of Smoke.

Samuel D. Warriner, Mem. Am. Soc. M. E., General Manager of the Lehigh Valley Coal Co., has been made Vice-President of that company. Mr. Warriner is now Vice-President and General Manager.

Samuel Whinery, Mem. Am. Soc. M. E., has been appointed by Governor Fort one of three commissioners to appraise and revalue the railroad and canal property in the State of New Jersey.

Henry S. Wood, Mem. Am. Soc. M. E., resigned May 1 as Eastern Agent of the North American Dredging Co., New York, and will open an office as a consulting engineer in the Park Row Building, New York. He will give special attention to dredges, dredging and reclamation of land.

E. P. Worden, Mem. Am. Soc. M. E., delivered a lecture on Modern Mine Pumping before the Engineers' Society, Milwaukee, Wis., April 14.

HISTORY OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Preliminary Report of the Committee on Society History

Chapter IX—*Concluded*

GROWING INFLUENCE OF THE SOCIETY

231 Prominent in the relations of the Society with the public may be mentioned the reports of the various committees appointed from time to time for the standardization of different portions of engineering work which had hitherto been conducted independently by various individuals and had lacked the systematic arrangement which could be given only by some such central body as The American Society of Mechanical Engineers.

232 Thus, the standard codes for testing steam engines and boliers, for standard duty-trials of pumping engines, and for tests of locomotives, provided methods which, however they may have been regarded in individual cases, placed all operations conducted under their methods upon a comparative basis. In like manner the standard system of pipe-flanges brought order out of chaos in a most important department of manufacturing work, and in this and similar instances the influence of the Society became extended beyond the limits of its immediate membership, and began to have its effect upon the general public, both as manufacturers and as consumers.

233 Another feature in the work of the Society which testified to its growing influence was the manner in which it entered upon the discussion of the economic side of mechanical engineering.

Under the direction of the Council the Committee on Society History has arranged to present the results of its investigations to the members of the Society. The Preliminary Report will appear in the Journal of the Society from time to time, enabling the matter to be open to comment during its completion. It is especially desired that any member who may be in the possession of facts or information bearing upon the various points as they are thus made public will communicate with the committee, in order that the final and completed report may have the advantage of the collaboration of the membership at large.

At the time when the Society was founded, it was the general opinion that the engineer or the mechanic had nothing whatever to do with the commercial or economic side of engineering work. Gradually it became apparent that the men who were competent to discuss the engineering features of important manufacturing enterprises were pre-eminently the ones who could undertake the development of the economic side of the same work. Thus arose the now firmly established plan which places in the hands of administrative engineers the organization and internal management of the works in which mechanical operations are conducted. From the original paper of Henry R. Towne, The Engineer as an Economist, through the epoch-making contribution of Frederick A. Halsey upon the premium system of wages, to the later discussions of F. W. Taylor, H. L. Gantt, and others, it has now become definitely settled that the mechanical engineer, of all men, is most competent to handle the economic side of engineering work; and in this transformation in public opinion and general practice The American Society of Mechanical Engineers must be accepted as the pioneer.

234 It has been said that the commercial development of the science of electrical engineering took place during the period between the foundation of The American Society of Mechanical Engineers in 1881 and the opening of the World's Fair at Chicago in 1893. As a matter of fact it is now being recognized that a large part of the work of the electrical engineer is included in that of the mechanical engineer, and reference to the Transactions of the Society during those memorable years will show the extent to which its members took part in the unfolding of the mechanical generation of electricity and its commercial and social applications. From the invention of the continuous-current electric generator by Gramme in 1868, through the work of Brush, Edison, Thomson, Houston, and their successors in the United States, and of Siemens, Ferranti, Hopkinson, and others in Europe, the mechanical engineer became the efficient associate of the electrical engineer. This is readily understood when it is considered that a large part of the generation of electricity includes the production of power and its delivery to the dynamo, while the construction of electrical apparatus calls for machine-shop work of a high order. It is not a matter for surprise, therefore, when we find in the Transactions of The American Society of Mechanical Engineers numerous papers relating to electrical matters, both as regards the production of the electrical current and its applications to the driving of machinery. The design and

equipment of large central stations has now become an important part of the work of the mechanical engineer, a work which had its inception largely among members of the Society, and to which much of their effort has since been directed.

235 In the tremendous growth of the iron and steel industry the work of members of the Society held an important part. It was by one of its founders, Alexander L. Holley, that the Bessemer process was introduced into the United States; a President of the Society, Robert W. Hunt, was one of the most energetic of its developers; another President, S. T. Wellman, was identified with the growth of the open-hearth process; while among other members who have done much to create the different types of the modern rolling-mill, there should be named two former Presidents, John Fritz and Charles H. Morgan.

236 In the development of the manufacture of iron and steel in the United States there is one name which stands pre-eminent as engineer, manufacturer, and philanthropist, that of Andrew Carnegie, a member of the Society for twenty years past, and always deeply interested in its work.

237 With the increase in general interest in the conservation of the natural resources of the country, it may be well to recall that almost from the origin of the Society its members have been quietly but most effectively reducing wastes, and seeking, as a part of their professional work, what has only recently been considered of public interest, the minimization of unnecessary losses in the "art of directing the great sources of power in Nature to the use and convenience of man."

238 In the very first volume of the Transactions of the Society there are four papers relating to the more economical use of steam, besides two discussing the reduction of friction losses, and two devoted to improvements in metallurgical processes.

239 A large part of the lifework of the late Professor Thurston was devoted to the furtherance of the economical use of steam, and hence a reduction of fuel consumption. One of the greatest contributions to the reduction of waste in the use of coal as fuel was due to the work of Eckley B. Coxe, in rendering practicable the utilization of small sizes of coal, and a résumé of his work in this field will be found in his presidential address of 1893.

240 The development of hydraulic power, and the possibilities of high efficiency by the scientific design of turbine wheels, have both occupied the attention of various members of the Society,

while improvements in machinery and methods of navigation are included in its work.

241 Another department of engineering work, in the progress of which many members of the Society have taken an effective part, is the mechanical handling of materials. The substitution of machinery for manual effort in this work has been very general during the period covered by the work of the Society, and the introduction of cableways, cantilevers, power-cranes of all kinds, industrial railways, belt-conveyors, and digging and dredging machinery of high power and great capacity, may be traced almost entirely to the activities of its members, among whom may be named two of its formei Presidents, C. W. Hunt and James M. Dodge.

242 The progress of heat engines using other fluids than steam has been most rapid since the period now under consideration, but some excellent work was done during the earlier years of the existence of the Society. The efforts of Captain Ericsson, apart from his experiments with the direct utilization of the heat of the sun, occurred before the foundation of the Society. An excellent review of the entire subject appears in a paper entitled Substitutes of Steam, by former president George H. Babcock, in 1886, while the later progress of the internal-combustion motor, and the interest in its improvement by various members of the Society, led in subsequent years to the formation of a special section devoted to this question, a matter which will be more fully noticed hereafter.

243 Thus it is seen that the Society, during the first twelve years of its existence, from its foundation to the first succeeding international exhibition held in the United States, had progressed from a comparatively small organization, of interest mainly to its own members, to a great National institution, contributing, through the work of its members, to the acceleration of the progress of the world, and extending its influence over the fields of manufacture, industry, commerce, and economics, not only in the United States but in all parts of the civilized world.

ADDRESS BY REAR-ADMIRAL MELVILLE AND PRESENTATION OF PORTRAIT

The Society enjoyed the privilege, during the Convention in Washington, of hearing an address by Rear-Admiral George W. Melville on the subject of The Engineer in the United States Navy.

At the close of the address a portrait of Rear-Admiral Melville, painted by Sigismond de Ivanowski, was presented by friends of Rear-Admiral Melville to the National Gallery. Walter M. McFarland, a friend and former subordinate of Rear-Admiral Melville, made the presentation address. The portrait was received for the Nation by Dr. C. D. Walcott, Secretary of the Smithsonian Institution.

Abstracts of the addresses of Rear-Admiral Melville, Mr. McFarland and Dr. Walcott are published herewith.—The Editor.

THE ENGINEER IN THE U. S. NAVY

By Rear-Admiral Geo. W. Melville, Ret., Past-President Am. Soc. M. E.

Ten years ago my presidential address before the Society had almost the same theme as my remarks this evening. At that time the Personnel Law was passed, which amalgamated the engineer corps with the line or executive officers of the navy, with the understanding that thenceforth engineering was to be the function of these line-officers. In his report as Chairman of the Personnel Board, ex-President Roosevelt, then assistant secretary of the navy, said, "On the modern war vessel every officer has to be an engineer whether he wants to or not." It is well that these lines should be constantly in mind, for they set forth the only justification for the Personnel Law.

2 Remarks have been made to the effect that a line-officer charged with all these duties would be a hybrid or Jack-of-all-trades. It is to be noted, however, that our naval officers have to perform definite duties. The curriculum of the naval school can be planned to give them a thorough and specific training for the work they have to do. In this respect these young men have a decided advantage over the students of any of our great technical schools, who can receive instruction only in general principles because

they themselves rarely know the particular line of engineering work which they will follow. It is, in my judgment, just as ridiculous to speak of our modern line-officers, specially trained for the work they have to do, as Jacks-of-all-trades, as it would be to apply this designation to a blacksmith, a lawyer or a doctor.

3 I have not forgotten that I am talking of men who go to sea and that the line-officers are responsible for the handling of the ships; in other words, that seamanship is an essential element of the training. It must be remembered that the modern navy has entirely dispensed with sails and that it is a misnomer to call the modern man-of-warsman, a sailor. He is not a sailor, because there are no sails for him to handle. He is a seaman, because he goes to sea. Seamanship is an art, proficiency in which comes almost entirely from practice, so that officers who are given the other portions of the training in the classroom, laboratory and workshop, get the requisite proficiency in seamanship from the practical exercises during their career as midshipmen at the naval school, and in the handling of vessels after they graduate.

4 It is natural to inquire how the amalgamation has worked out in practice. On January 21 of this year, the chairman of the House Naval Committee quoted from the remarks of the officer who commanded the battleship fleet which cruised around the world, to the effect, "When I got to California, without any engineers, my fleet was in better condition than when it started." It would seem, however, to have agreed much better with the avowed intention of the Personnel Law if he had said, "Our cruise was a great success because every officer was an engineer."

5 The Chairman of the House Naval Committee further said, "It is the opinion of our naval officers, in command of our fleet and ships, that this consolidation has been a splendid thing for the navy, because it makes the man in command of the ship the master of the ship, a man who understands all the workings of the ship. Before, the command of the ship was in the hands of the engineer. We had to make a change in the curriculum of the Naval Academy whereby the officer of midshipmen there must acquire a knowledge of engineering, further adding to that the experience which he must obtain in the engine room as a watch officer. By reason of these facts, the entire ship is today under the command of an engineer officer, a man who understands all the duties of engineering and who is complete master of the ship."

6 I have been told by officers who have recently served on

board ship that one great benefit has resulted from the amalgamation: namely, that the idea just expressed in the above quotation is true; that the commanding officer is now the master of the entire ship. In my early days, few commanding officers felt any interest in the machinery beyond their demand that it should always be ready for service. If anything went wrong, they washed their hands of the responsibility, which was naturally upon the special body of engineers. They now feel the same keen interest in the machinery that they do in the guns or any other part of the ship, and the chief engineer of the ship (still so-called) is generally looked upon as the officer next in importance after the captain.

7 The part of the new régime about which I have felt misgivings is that thus far there has been no systematic effort to assure training and experience for every line-officer in connection with the motive power. Every young officer should be required to serve an apprenticeship in the engine and fire-rooms, just as he does on deck, but so far as I have been able to learn there has never been careful attention given to this point.

8 Having touched upon the general conditions of the executive side of engineering as affecting the operation and integrity of the machinery at sea, it is now pertinent to consider the prospects with regard to present and future designs. Thus far, this work has remained in the hands of officers specially trained. Unfortunately, the same condition is found here as mentioned in the previous division of the subject. An effort has been made to arouse the interest of some of the younger line-officers by a course of special training for this most important work after the present highly competent and experienced men have retired. There has, however, been no settled policy for this, and the attempt that was started was interrupted by the cruise of the Atlantic Fleet.

9 I am very glad indeed to bear testimony to the fact that the recent designs of the Bureau of Steam Engineering have been highly creditable in every way. In saying this, I feel a touch of personal pride for the reason that the men who have been doing this work were formerly my assistants and received most of their experience during my term of office. I am naturally pleased that the record which was made during my own term is being maintained.

10 When such praise as this can be given in simple truth, what can be thought of the official who plans to discredit the men who have made such a record, and destroy the autonomy of the Bureau by subordinating it to the Bureau charged with the design of hulls?

I believe you will agree that my service of a lifetime in the Navy and my record as the head of a great Bureau in the Department, the longest since the Civil War, entitles my opinion to some weight, and I want to register my earnest conviction that any such scheme of consolidation can only bring inefficiency, retrogression and waste.

11 There is still another side to engineering in the navy; namely, the work of the navy yards, which has been prominently before the public during the régime of the last Secretary of the Navy. Changes have been made abolishing the separate departments in the navy yards and consolidating their administration under one officer, whose work, while a vital element in the building of a ship, was certainly not the only important part and moreover was so different in its nature from the other departments which were absorbed, that it is obvious he could not be an expert on these other lines. To me it was so marvelous as to be almost beyond belief that in this age of specialization a movement so absolutely counter to the spirit of the age should take place in the name of economy and reform. If the great shipyards in civil life, or the great manufacturing establishments, or the dockyard administration of other countries, had been different from the methods employed in our navy yards, a change would at least have been indicated; if, in the other places to which I have referred, a system somewhat like the one which it has been attempted to introduce in our navy yards, was in vogue, there could be some understanding of the change: the facts are however, that in its essential features our navy yard administration was along the very lines which obtain in foreign dockyards, in the great shipyards at home and abroad, and in our great manufacturing establishments.

12 I am led to believe that the present Secretary is giving the matter very careful consideration with a view to undoing the tremendous harm brought about by his predecessor, and I trust he will be well-advised and will restore the yards to their former efficiency. It ought to be said, however, as a matter of record, that these changes were made without any consultation between the late Secretary and the officers most competent from long experience to know what was best. Indeed, by his own statement, the scheme was evolved from his own inner consciousness.

13 Our modern navy is essentially an engineering affair. The vessels themselves are the product of the engineer's brain, and their successful maintenance and utilization depend entirely on engineering skill. Ten years ago I said that the change which had been

made, absorbing the engineer corps into the line of the navy and making every officer an engineer, was a tremendous step forward, *provided* a sincere and earnest effort was made to carry out the scheme which was thus outlined.

14 From what I have said this evening, it will be clear that I am not as yet satisfied that this has been brought about. Undoubtedly the responsibility for the machinery of our vessels, guns, motive machinery, electrical machinery, torpedoes, etc., is upon the line-officer of the navy. He is charged with this duty by law. If the older officers of the navy had taken hold of this matter with enthusiasm, I believe that it would now have been settled and there would be no question as to the great success of the new officer, the line-officer of the twentieth century. I am not willing to believe (and indeed hardly willing to consider) the possibility that naval officers will neglect any duty with which they are charged, and I still hope that the scheme will be worked out to a great success.

15 Not much is ordinarily said about the machinists who are doing good work on board our vessels. They look after the routine work of repair and adjustment on board ship, but they are without the scientific training which is required for engineers who are really qualified for the duties comprehended by that title. If the line-officers of the navy do not maintain engineering efficiency, it will then, as the organization now stands, fall upon these machinists to perform the work of the engineers. In other words, in an organization whose efficiency is absolutely dependent upon the skill of engineers the men relied upon for such work would be relegated to a position of inferiority so low that they are hardly counted. This is utterly un-American and can only be matched by absolute monarchies or countries as unprogressive in the mechanic arts as Spain. The speedy destruction of her navy in the war of 1898 was due even more to her utter incompetence in engineering than in gunnery. It is inconceivable that self-respecting men in a free country like ours will attempt to perform work of such vital importance without adequate recognition in the way of rank and position.

16 I will not permit myself to believe that we shall have to consider this as a practical question because I cannot conceive that naval officers would fail in duty, but I have felt that both sides of the question, so vital to our naval efficiency, should be presented.

17 During my entire career in the navy, it was my constant endeavor to show by my work the importance of the engineer and to encourage that spirit in my subordinates. I trust I will not be

accused of vanity if I say that I believe my record as engineer-in-chief added a little to the reputation of engineering. My active work in the navy is done, but so long as I live my interest will never slacken and my voice will always be raised to encourage efficiency in every branch of the service.

PRESENTATION OF PORTRAIT

Address by Walter M. McFarland in Presenting a Portrait of Rear-Admiral Melville to the National Gallery

The honor of being invited to pay a tribute to my dear old Chief, Admiral Melville, is one which I appreciate highly, as well as the allied one of acting as spokesman for the donors of the splendid portrait which is to be presented to the National Gallery this evening. I admire the Admiral as the fine flower of a splendid type of manhood, and his kindness to me for many years has been so like a father's that with a son's affection I rejoice at this splendid testimonial to his personality and his work.

2 Too often the pathway to greatness and fame is marked by the wreckage of competitors, and even friends, who have been ruthlessly thrust aside in the egoism of selfish ambition. Then, there may be a grudging admission of ability, but there is no love, no true admiration. When, on the other hand, the hero has always been the helper and friend of his companions, when he has cheerfully acknowledged their aid to his success, we have such greatness as we are celebrating tonight. Then, every member of the profession feels that the fame of the leader is reflected on the whole body, and they love the man while they rejoice in his reputation.

3 George Wallace Melville is such a man. He has been one of the famous men of engineering so long that we find it hard to remember a time when his name was not synonymous, as it is now, with all that represents progress and achievement in our profession.

4 It is a matter of delight to all of us who love him that the artist, in the picture which is to be presented to the National Gallery this evening, has faithfully depicted the chief characteristics which have made him great. These are, in my judgment, indomitable courage and unbending honesty. It is possible for a man to have great mental ability and yet fail of true greatness if he lack these essentials.

5 You all know Melville's Arctic record, which first brought him an international reputation; there he displayed a heroic courage which has never been surpassed, and for which Congress advanced him a grade in the Navy. This, however, was only a repetition of other instances of absolute fearlessness, beginning with his earliest days in the Service. When he became Engineer-in-Chief, the same courage, but rather on the moral than the physical side, was shown. Beginning with his first annual report, he spoke out fearlessly, setting forth the truth as he saw it and striving always for advancement and efficiency. Complaint was made to President Cleveland of the plain speech in this first report, but that strong man read it himself and said, "We want more such men."

6 His professional courage is also remarkable, and along with this is a faculty, which I believe is a characteristic of all great men, that having made his decision he does not worry about the result. Able men of minor rank are always fearful that something may go wrong and their reputation be injured. The really big man does not believe himself infallible. He knows that all men who *do* things will make some mistakes, and he is strong enough not to dread them. A notable instance of this kind in Melville's career was his use of triple screws for the Columbia and Minneapolis. I saw letters from some of his friends, for whose professional opinion he had the highest regard, urging him not to make the experiment. but he had studied the problem carefully, was satisfied with the correctness of the solution, and persevered. The result was perhaps the greatest triumph of his professional career.

7 His ability as an executive was of a very high order. The feature of deciding a case and then refraining from worry is an evidence. He had a rare talent for choosing able assistants, and having proved them he left in their hands all the detail work, thereby giving himself time for careful study of the larger problems. The effect of this was very marked in stimulating the entire staff to the highest efficiency and zeal. I have known them all personally, and every man counted it a pleasure to work, without regard to hours, for the credit of the "Chief" and the glory of the Service.

8 With respect to his professional work, it is notable that his career as Engineer-in-Chief of the Navy, from 1887 to 1903, is the longest on record. It covers the building of the "new navy," and the Spanish war. During this time he was responsible for new designs of machinery for about 120 vessels, among which were 24 battleships

and 41 armored vessels. Best of all, there were no "lame ducks," and no failures.

9 I will mention briefly some details of his more important work. He was the first to use water-tube boilers in large war vessels and to determine the actual coal consumption by trials. He was also the first to use the method of determining trial-speeds, known as the "standardized screw," which is the simplest, most accurate and inexpensive, and fairest to the contractor as well as to the government.

10 It is to him also that we owe our first high-speed battleship. When in 1898 the proposals for the Maine, Missouri and Ohio were being prepared, he stood alone in his demand for 18-knot ships. If he had not persisted, we should have been three years longer behind the other navies of the world in battleship speed.

11 It is very interesting to note also that only a little after this he proposed an "all-gun one-caliber ship:" in other words, what is now called the "Dreadnought" type. Before I left the Service, I had often heard him talk of this big ship with ten twelve-inch or twelve ten-inch rifles and nineteen or twenty knots speed; and about 1899 he submitted a sketch plan of the battery of such a ship to the Board on Construction. Possibly the same influence which almost prevented the eighteen-knot battleships prevented consideration of this more advanced type. At all events Melville was in advance of the general naval mind, and our country lost the credit for the introduction of this revolutionary improvement which it might have had several years before the "Dreadnought" was disclosed.

12 During the war with Spain he brought out the repair ship and the distilling ship. The idea of the former was not new, but the Vulcan was by far the most complete vessel of the kind equipped up to that time. The latter furnished fresh feed-water to the boilers and enabled a vessel with a storage bunker capacity of 3000 tons to supply 60,000 tons of water.

13 A clever piece of work at this time was the fitting of new boilers to some of the old Civil War Monitors to enable them to be used for harbor defense. For years Melville had advised the Navy Department that new boilers must be supplied before these vessels could be used. When the destruction of the Maine made the outbreak of hostilities seem probable, the makers of water-tube boilers submitted estimates of time and cost for the work. Boilers were promised in 30 days, but it was necessary to use the standard land type. As these vessels were not to go to sea, however, this was

satisfactory. The wornout boilers were cut up and passed out through the smokepipe (because the armored deck could not be taken up; the new boilers were passed down the smokepipe in sections and erected on board; finally each of the boats was given a steam trial, which was entirely successful.

14 A great deal of experimental work was done under his direction, all of which is published in his annual reports. The last of such experiments was a series of tests of oil-fuel, probably the most comprehensive ever made.

15 My brief sketch of this famous man would be incomplete if I failed to speak of his personality. The lion-like head and the frank speech have led some to say that he is one of the old "Vikings," spared to us a thousand years after the others have gone; but if this leads any to think that he is harsh and cold, there could be no greater mistake. Like all strong natures, he is pronounced in his feelings, but he is a man of warm affection, and when he has once taken you into his heart, you are sure of an abiding-place there as long as you are worthy. It is often said that no man is great to his intimates, but I have been with him, day by day, for years; have seen him under all conditions; and my admiration and love for him have simply increased as the years go by. I have no ambition to be a Boswell and I have not kept notes of his doings; but I have seen the daily workings of a great, kind heart, tender for the humble yet fearless toward the great; and I can truly say that I count it a privilege and an inspiration to have been a trusted friend and helper of this noble man, who has exemplified the highest type of manhood and added new luster to the profession of engineering.

ACCEPTANCE BY DR. C. D. WALCOTT

It gives me pleasure, speaking for the Smithsonian Institution as the custodian of the National Collection of Art, to accept from you for the people of this country this fine portrait of Rear-Admiral George Wallace Melville, to be exhibited in the gallery of portraits of Americans who have achieved eminence in their life work.

2 Among the men who have rendered distinguished service to their country in literature, science, or art, in war or in peace, in professional or civil life—few have won such well-merited distinction in so many lines of duty as Admiral Melville. He stands high in the regard of the Nation as a naval hero, as an engineer of exceptional ability, and as a wise and resourceful administrator and

advisor. It is only to be regretted that, under the operation of law governing retirement, Admiral Melville was obliged to retire from active duty in 1903, but it is to be hoped that the country which he has so efficiently and actively served may long be permitted to enjoy the benefits of his counsel.

3 The portrait of Admiral Melville is a most appropriate addition to this National collection and it is peculiarly fitting that his services should be emphasized in this happy manner by a Society which embraces so distinguished an array of men in the engineering profession, a Society that for nearly thirty years has exercised a powerful influence toward unity of interest and harmony of purpose in the broad field of American engineering.

DISCUSSION ON PAPERS PREVIOUS TO SPRING MEETING

THE PHYSICAL PROPERTIES OF CARBONIC ACID AND THE CONDITIONS OF ITS ECONOMIC STORAGE FOR TRANSPORTATION

By Prof. R. T. Stewart, Published in The Journal for November

ABSTRACT OF PAPER

This paper gives the results of recent investigations into the physical properties of carbonic acid, necessary in investigating the strength and safety of existing carbonic acid cylinders and in the design of new cylinders on a safe and economic basis.

The results of this investigation have made it possible for the first time to state the conditions under which the weight of the containing cylinder will be a minimum for the customary conditions of storage and transportation of carbonic acid.

The paper is accompanied by very complete tables, covering, it is believed, a range of conditions sufficient for the solution of any problems apt to arise regarding the physical properties of carbonic acid in connection with its storage and transportation. Of these, Table 4 will be found most useful for the investigation of the strength and safety of existing cylinders, and Table 5 for the designing of new cylinders of minimum weight of steel in the shell per unit weight of acid contained.

There is also an addendum showing the necessity of a further investigation of the carbonic acid cylinder problem, especially as regards the most suitable steel for cylinder construction and the safety of cylinders now in use.

DISCUSSION

Mr. John C. Minor, Jr.[1] Professor Stewart has taken up with admirable thoroughness a most important subject hitherto practically neglected by technical authorities. The necessity of the data which he has so fully worked out, in the proper and safe design of cylinders, cannot be questioned.

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[1] John C. Minor, Jr., Manager N. Y. Carbonic Acid Gas Co., Saratoga Springs, N. Y.

2 Much credit must be given to the British Commission, which in 1896 was the first to investigate the safety of high-pressure gas-containers; they confined themselves, however, to the consideration of accidents and to drawing up specifications for standard containers, and suggesting regulations for the future conduct of the business. It does appear, as Professor Stewart says, that they were in some respects supplied with incorrect data, but their errors were in the direction of safety, and measured by results, the report of that Commission marked a tremendous advance. Its suggestions never became law, but were adopted in their entirety by the gas manufacturers, with the result, as I am informed, that there have since then been no explosions of cylinders whatever in Great Britain. Professor Stewart's investigation will, I trust, lead to an equally beneficial outcome in this country.

3 While the trade in compressed and liquefied gases has not in this country reached the proportions to which it has attained abroad, it is nevertheless of considerable volume. It is here largely confined at present to carbonic acid, with but a small production of other gases, although the oxy-acetylene welding process is rapidly bringing high-pressure oxygen into use. With Buffalo and Pittsburgh as western limits, and Philadelphia on the south, there are probably 500,000 cylinders a year of all sizes circulating in the East. This industry has been going on ever since 1888, and with remarkable freedom from accident.

4 With present practice it takes 70 lb. of steel to carry 20 lb. of gas, and high rates on the railroads make the freight bill perhaps one-fourth of the whole expense. Hence temptation manifests itself in two ways: the manufacturer wants to make his tubes as light as possible in order to obtain the business, and may be prodded, if unwilling, by the buyer, who sees the possibility of reducing freight expense. The gas-producer, on his side, for every pound of gas put in the cylinder over a safe load, gets increased work and reduction of expense. I believe that the author has called a halt on all this in time to prevent the situation arising here, as in Germany, where competition carried the weight of cylinders down until the record of accidents brought governmental interference.

5 In his determination of the proportionate space occupied in a cylinder by gaseous and liquid CO_2 the author reaches conclusions whose accuracy will not, I think, be questioned. These are shown

in Table 5, which well illustrates the value of this investigation, as the most recent contribution on this subject (by Lange in the Zeitschrift fur Angewandte Chemie, 1903, p. 511) gives figures at wide variance from those of Professor Stewart.

6 The author brings out the fact that with a filling of 62 per cent, i.e., with 56 lb. of CO_2 in a large cylinder, the entire cylinder volume is filled with liquid, and all supernatant vapor condensed, at temperatures between 84 and 86 deg. In England, where the regulations permit 66 lb. of CO_2 in this size of cylinder, this condition arises at temperatures above 70 deg.

7 Assuming the slight solubility of air in liquid CO_2 indicated by the author, an assumption which my own experiments do not yet tend to prove, what becomes of the air originally present in a tube thus completely full of liquid CO_2? If it is not dissolved, would the suggested allowance of 60 lb. additional pressure for each 1 per cent of air be proper in determining the actual pressure to be expected under these conditions?

8 One point in connection with the economics of design is brought out strongly if we compare our American cylinders with those of England, where a filling of 66 lb. is permitted in the size cylinder which manufacturers here recommend for 50 lb. They use a low carbon steel and put in more metal, 120 lb. I think, to our 100 lb. They thus incur a proportionately lower freight per pound of gas, and have the still greater advantage in increased storage capacity. Not much CO_2 is sold in winter, at which time the cylinders serve as storage reservoirs rather than containers for transportation. Any slight additional cost would be welcomed, therefore, which without changing the conditions of safely would insure an increase of storage capacity of 30 per cent.

9 I probably do not interpret Fig. 9 correctly, but on applying it to the two types of cylinders in common use, holding respectively 20 and 50 lb. of CO_2, the following results appear with reference to the most economic condition of storage; assuming a maximum temperature of 120 deg. the weight of the shell should be 3.05 times the weight of the contained acid, and hence the weight of a cylinder for 20 lb. of CO_2 should be 62 lb. In practice it averages 70 lb. But cylinders to hold 50 lb. of CO_2, according to Fig. 9, should take 155 lb. of metal under the same conditions, whereas these cylinders in use average 100 lb. I shall be glad to admit what I feel sure is my error, if it will aid me in interpreting one of the most important results of the investigation.

10 It is clearly brought out that protection against accident is not afforded by hydraulic test alone, on which complete reliance has hitherto been placed; provision must be made for tests of the character of the metal and its ability to stand usage. The new German regulations apply these only to new cylinders, and not to those in use, which seems essentially wrong.

11 The metal in use abroad for cylinders is so different that we cannot adopt the same regulations for testing, and much remains to be done along the lines here pointed out to provide for the safety of these containers. The question arises whether periodic renewals of the hydraulic test should not be made on all cylinders, and if so, what pressure should be set for it. Should not a certain number out of every thousand old cylinders be also subjected to an examination of their ductility, and what figure should here obtain?

12 I believe that the result of this investigation will be not only to provide data for standard specifications of new cylinders, but to induce on the part of producers of CO_2 a careful examination of all cylinders now in use. I have been assured of the concurrence of several companies in this effort to weed out dangerous tubes, and by periodic inspection and test to maintain conditions of safety, and we shall be glad to render all possible assistance, by the contribution of tubes for examination and test, etc., in any further investigation.

13 The great freedom from accident of the CO_2 industry in this country has been due mainly to our good fortune in having tubes furnished us that were better than we had reason to expect, and which have stood, almost without exception, hard usage for years. To what we have gained from good luck we may now hope to add the advantages resulting from the application of common sense along the trail blazed by the author.

Mr. Herman E. Stürcke.[1] In a general way, the scientific part of this paper may be accepted as substantially correct. The writer would like to call attention, however, to the figures of Thiele and Deckert (Zeitschr. für angew. Chemie, 1907), showing that 1 per cent of foreign gases causes a pressure increase of about 75 lb., as against *60 lb.*, as stated. The author may also learn there of a possible error in some of his experiments. His method of determination of foreign gases at a temperature above the critical point materially facilitates the solution of the problem of the influence of foreign gases.

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[1] Herman E. Stürcke, General Manager, Crescent Chemical Manufacturing Company, Brooklyn, N. Y.

2 As a manufacturer of carbonic acid, the writer welcomes the author's investigation, but does not agree with his conclusions and recommendations. It is not clear to him why the author should come to his conclusions only now, after having the data for over four years. Knowing my fellow-beings to be in imminent danger, and in ignorance thereof, I am either very careless in fulfilling my duty, if I postpone the warning cry, or else the danger is more imaginary than real.

3 On May 26, 1904, at a meeting of carbonic acid manufacturers the author stated that he had made for a cylinder manufacturer a very thorough inquiry into the physical properties of CO_2 as bearing upon the questions of storage and transportation, and that, while the investigations had not yet been completed and formally reported to the cylinder manufacturer, he had been granted the privilege of submitting the tables and charts then ready. The author at this time stated his belief that the standard cylinders of that company were entirely safe, with the most economic filling at 62 per cent, at a temperature not to exceed 110 deg. fahr., and at a maximum of 3 per cent of air present.

4 The author also gave as the factors of safety, for seamless cylinders

at 110 deg. fahr., for 55 per cent, 4.1; for 66 per cent, 3.4
at 130 deg. fahr., for 55 per cent, 3.25; for 66 per cent, 2.6

for lapwelded cylinders

at 110 deg. fahr., for 55 per cent, 3.7; for 66 per cent, 3.23
at 130 deg. fahr., for 55 per cent, 2.9; for 66 per cent, 2.48

and further stated: Seamless cylinders generally burst between 5100 and 5900 lb. pressure; lapwelded cylinders between 4900 and 5500. The manufacturers present certainly carried away the conviction that the manufacturer who had commissioned the author with the investigation was supplying safe cylinders. He should enlighten us as to why he now differs from this opinion.

5 In 1904 the author knew of only five explosions of CO_2 cylinders. The writer knows of only two explosions in the United States since that date and both were caused by overloading and undue exposure to heat or excessive shock. During the 24 years of the existence of the CO_2 industry in the United States, seven or possibly eight cylinders have exploded, with a loss of two lives: on an average one explosion in three years, or about one cylinder in 5,000,000 cylinders filled. This estimate does not, of course, include explosions caused by fire, or explosions of soda-water tanks and car-

bonating apparatus, frequently reported in the press as explosions of carbonic acid cylinders.

6 This very small proportion of explosions is likely to decrease still further on account of the gradual adoption of safety devices, and the greater care which manufacturers take to prevent overloading. The seamless cylinders, now mostly used, have a water-capacity of 88 to 92 lb., and are seldom filled with more than 50 lb. or 51 lb. of carbonic acid, giving a filling of about 55 or 56 per cent, or 10 per cent less than the 62 per cent claimed by the author as most economic, with a pressure reduction of 10 per cent and more at the danger point.

7 From personal observation and experience I know the English cylinders, of which the author speaks so highly, to be clumsy, unhandy and thick. They are, of course, safe, but their good record is partly due to their low pressure safety device. The carbonic acid industry is not so prosperous that it could carry the heavy burden of English cylinders and American customers would prefer their old system of marble dust and acid to the use of English drums.

8 As for the light German cylinders, one of the oldest American companies, which uses these exclusively, and has around 30,000 in constant service, has not lost one cylinder in twenty-two years by explosion in service or in transit. Used with reasonable care German cylinders are not as black as sometimes painted.

9 In Germany the regulations permit loading to 75 per cent water capacity. At 120 deg. fahr., a loading of 55 per cent gives a pressure of 1630 lb., 75 per cent gives a pressure of 2450 lb. If this were reduced to 55 or 60 per cent, few explosions would be heard of, especially if safety devices should become more general. Of the eleven explosions of CO_2 cylinders in transit or in service between 1894 and 1902, in Europe, three only were caused by poor material (in 1896 and 1897); the other eight by overloading and exposure to the hot sun, hot water, a red-hot stove, etc. Explosions of German cylinders have occurred since 1902, and will continue, official testing notwithstanding. Why then impose upon the American CO_2 industry a burden which does not protect, and causes endless expense and annoyance? The disastrous consequences of a compulsory change of cylinders have been experienced in Germany. When the light steel cylinders came into use there, five companies could not survive the change.

10 Opinion has been expressed to the writer by a competent authority to the effect: "We believe as you do that with the 500,000

American-made drums in the United States, the explosions that have taken place have been infinitesimally few and we do not know of an instance of an explosion of cylinders such as you use, except on account of overloading."

11 If the author intends to secure for all interested more protection against explosion he can attain this end by a practical scheme to avoid overloading and by developing safety devices.

Mr. Graham Clarke.[1] Our company has been engaged in the gas business for 25 years. We have about fifty thousand cylinders in which to store and transport carbonic acid gas, nitrous oxid and oxygen; and we have never had a cylinder explode. Our cylinders are filled on an average four times a year and are shipped to all parts of the country. We have always bought our drums from reputable makers, believing it would be to their interest to safeguard their business by giving us the most suitable material and the best workmanship. While the cylinders come to us tested, we give them an additional hydraulic test in our factory.

2 While Professor Stewart thinks this test is not of great importance, we feel, from our past experience, that it has served us well. We plan to re-test our cylinders as nearly as possible at intervals of five years. We have apparatus for determining permanent stretch and test a certain number for this to see if there is any deterioration of the cylinders with age. If a cylinder shows a permanent stretch of any extent we destroy it. When cylinders of a make unknown to us come into our factory for refilling, we have them tested.

3 In filling drums it is very important to see that they are not overloaded. Our drums are all weighed at the filling-stand, and tags giving the gross, tare and net weights are put on them. The weight of the empty cylinder is stamped on the side of the metal valve. These drums are then put in stock, and before being shipped they are reweighed. This double check serves as an extra precaution to make sure that the drums are not sent out overcharged.

4 From our long experience we believe the drums now in service are of sufficient strength, if properly tested, and not over-loaded, and while we would welcome any rules, yet we believe the manufacturers of gases, who know the practical side of business, should be consulted in regard to them.

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[1] Mr. Graham Clarke, General Manager, Lennox Chemical Co., Cleveland, O.

Mr. L. H. Thullen. The manufacturers of carbonic acid in this country have made numerous experiments to ascertain the pressure-rise with increase of temperature and with different degrees of filling. These figures were made for their own use, and have not been published to any extent. They have made also extensive tests of cylinders for bursting-pressure and ductility, and by chemical analysis.

2 Cylinders in general use here will contain 20 and 50 lb. of carbonic acid, and are generally 5 in. and 8 in. respectively in inside diameter, and 50 in. long. The 5-in cylinders are generally made of ¼-in soft steel, having a tensile strength of 60,000 lb. per square inch. Some of the 8-in. cylinders are made of high grade steel of 95,000 lb. tensile strength, and have a ¼-in. wall.

3 Some of the cylinders are made in this country and a large number imported, some of high-grade steel coming from Germany. Cylinders are imported not necessarily on account of their superior quality, but on account of the difference in price between the domestic and imported article. The high price of domestic cylinders is due to the same cause that makes steel rails sell at $28 a ton in this country, while sold abroad by the same company, freight paid, for $22 a ton.

4 There are in use here by manufacturers of carbonic acid about 600,000 cylinders of different sizes. These cylinders are charged about four times a year, making a total of 2,400,000 to 3,000,000 cylinders charged a year.

5 In the last 20 years there have been, from different causes, about half a dozen explosions of carbonic acid cylinders. Practically all these explosions were due to gross carelessness in handling and storing the cylinders, the majority being caused by the cylinders being subjected to a high temperature. Conditions that result from this latter cause may readily be seen by referring to Professor Stewart's table of pressures for different temperatures.

6 On this basis there has been about one explosion to 5,000,000 filled cylinders in the last 20 years. It is safe to assume that a larger ratio of loss of life has resulted from the overturning of teakettles.

7 The author leaves us under the impression that the proper filling for carbonic acid cylinders is about 60 to 62 per cent of their water capacity. I am of the opinion that a filling of about 55 per cent would be more correct. This would make a pressure on the walls of the cylinder of about 2000 lb. per square inch; at a temperature of 130 deg. fahr., the gas containing about 3 per cent air, which is the maximum contained in commercial carbonic acid. A tempera-

ture of 130 deg. fahr. is about the temperature that a metal object lying out in the sun would attain when the temperature in the shade is 90 deg., and as these cylinders are apt to be in the sun at some time, I think 130 deg. fahr. should be the maximum.

8 It is not logical to build the cylinder walls of sufficient thickness, or have the factor of safety sufficiently large, to meet a rise in the temperature under extraordinary conditions, such as fire, or for excessive filling. Such conditions should be cared for by means of a safety valve or safety device of some form. The means generally used is a soft metal disk, that ruptures, and exhausts the cylinder, when the pressure reaches a predetermined point below the yielding point of the metal and well below the rupturing point. This has been found to give ample protection, as demonstrated by the small number of explosions; and there is no more reason for designing a carbonic acid cylinder to meet all pressure rises than for designing a boiler to meet all increases of pressure with no safety valve.

9 I am of the opinion that the safety device on the carbonic acid cylinders should be so designed that an increase in temperature would make a decrease in the releasing point of the valve. Such a device could be in the form of a disk composed of a substance that had a yielding point at a comparatively low temperature. There are a number of substances that would fill this requirement.

10 With a safety device to release the pressure at a point corresponding to a temperature a little above the assumed maximum, it would be safe to design the cylinders with a moderate factor of safety; 3.3 under these conditions would be ample. This would correspond to a fiber strain of 20,000 for steel having a minimum tensile strength of 65,000 lb. per square inch, and would be well below the yielding point of steel having a tensile strength of 35,000 lb. Soft steel for cylinders should have a tensile strength of not less than 65,000 lb. per square inch, a yielding point of not less than 35,000 and an elongation of not less than 25 per cent in 8 in.

11 As a 5-in. cylinder generally contains but 20 lb. of carbonic acid, and an 8-in. cylinder 50 lb., valued at 4 cents per pound, or 80 cents and $2 respectively, and the empty cylinders when made of soft steel weigh 70 and 100 lb. respectively, the freight rate being about 35 cents per hundred, it is apparent that a great effort should be made to decrease the weight of the empty cylinders. In fact, good engineering in cylinder design requires steel of the highest tensile strength consistent with reasonable ductility, and steel that will not deteriorate in physical quality while undergoing manufacture

into cylinders. At the present stage of the steel industry, steel of a tensile strength as high as 100,000 lb. per square inch would be perfectly feasible for use.

12 The following would be good specifications for such steel:

Phosphorus (basic)	not to exceed	0.03	per cent
Phosphorus (acid)	" " "	0.05	" "
Sulphur	" " "	0.03	" "
Carbon	" " "	0.60	" "

Tensile strength not less than 100,000 or more than 115,000.
Elastic limit not less than 55,000 or more than 65,000.
Elongation not less than 12 per cent in 8 in.

This would make a cylinder of reasonable weight, which with a calculated maximum temperature of 130 deg. and the proper pressure-releasing device would be perfectly safe with a safety factor of 3.3 or a fiber strain of 30,000 lb. per square inch.

13 With a maximum calculated pressure of 2,000 lb. per square inch, the thickness of the 5-in. and 8-in. cylinder walls would then be 0.16 in. and 0.26 in. respectively. Cylinders should not be tested to the yielding point; in fact, I would recommend a hydrostatic test at not to exceed 80 per cent of the yielding point. This test should be made only to detect any leak, imperfection of manufacture or thin spot in the cylinder.

14 I understand that in some countries it is customary to anneal the cylinders periodically; my opinion is that this would be detrimental to the cylinders and add an unnecessary burden to the manufacture of carbonic acid gas. Considering the small percentage of accidents in this country during the 24 years of the manufacture and transportation of carbonic acid gas, I see no reason for laying great stress on further investigation, unless it be along the line of making the cylinders lighter, and using high-grade steel, thus reducing the cost of shipment of this and other compressed gases.

Mr. E. D. Meier. I want to speak simply to the question of the composition of the steel in the cylinders. I do not think any comparison of the three statements in the paper is possible, for the simple reason that they do not state the amount of phosphorus or sulphur in the steel. I speak from the standpoint of the boiler manufacturer: the problem is similar to ours except that we have to do mainly with cylinders under conditions of great heat, whereas with the carbonic acid cylinder you are dealing with cold. We know that phosphorus makes steel what is called by the mill men "cold short," that is, more likely to break or crack when cold. Sulphur makes steel "red short," that is, likely to crack when in a heated condition. I believe that the difference between English and German cylinders may be explained by the percentage of either metalloid. Then again the German cylinders of 95,000-lb. tensile strength contain a slight percentage of nickel or vanadium, which would put them in a different class.

2 I take issue with Mr. Thullen with regard to the percentage of phosphorus. Phosphorus is bad for any steel where you have much tensile stress, and there is no reason, except possibly a commercial one, for permitting more phosphorus in acid steel than in basic steel, simply because it is easier to get it out of the basic steel. The danger of an excess of phosphorus is very great. I have investigated a number of ruptures of plates that occurred after flanging, and in every single instance, taking the chemical analysis from borings near the point of rupture, it was found that the rupture was due to high phosphorus.

3 A very searching investigation was conducted by Charles L. Huston a few years ago in regard to the segregation of the metalloids. He found that in the ingot the metalloids segregated into a series of parabaloids, with the wide end at the top of the ingot, and therefore in order to make good boiler steel more must be discarded from the top of the ingot than formerly; and I do not think any specification for a vessel to contain liquid or gas under pressure is sufficient unless it gives also the percentage of phosphorus and sulphur.

Mr. Sanford A. Moss. I have been interested in comparing the pressures of saturated vapor given by Professor Stewart with those deduced from other experiments. There are some slight differences, but on the whole, the agreement is close.

2 In an investigation of experiments on vapor pressure of solid CO_2 and liquid CO_2 below 0 deg. cent.,[1] I found that the following equation gave vapor pressure of liquid CO_2

$$\text{Log}_{10}\, p = 45.8372 - 1 \div \left(0.025975 - \frac{0.4992}{T}\right) \qquad (2)$$

Here p is vapor pressure in mm. Hg (760 mm. = 1 atm.), and T is absolute centigrade temperature.

3 This equation fitted observations with remarkable accuracy from pressure of about three atmospheres for super-cooled liquid

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[1] Physical Review, vol. 26, No. 6, June 1908, p. 439.

at -65 deg. to pressure of about 20 atmospheres at − 20 deg. cent. The critical point is also given by the equation.

4 I find that the vapor pressures given by Professor Stewart agree with values computed from this equation in the vicinity of the critical pressure. As the pressure becomes lower, there begins to be a slight divergence, and at 0 deg. cent. there is a difference of about 2 per cent. Below 0 deg. cent., the equation agrees almost exactly with the experiments of a number of observers.

TABLE 1 VALUE OF VAPOR PRESSURE OF CO_2 IN ATMOSPHERES (760 mm. Hg)

Degrees Cent.	Computed Value	Amagat's Value
0	34.9	34.3
10	45.0	44.2
20	56.9	56.3
31	72.4	72.3

5 Values given by various observers for the critical point agree very closely with those of Amagat. Lowest reputable value is 31 deg.

PROF. WM. KENT. Referring to Professor Stewart's statement in Par. 134, "Any scheme that necessarily overstresses the good cylinders in order to eliminate the occasional defective ones is highly improper," will a proof test of 1.5 times the working load overstress the cylinders? Suppose the yield point to be 37,000 lb. and the maximum working fibre stress 20,000 lb., what harm can be done by a proof test that stresses the metal to 30,000 lb. This would cause an elongation, elastic, not permanent, of only 0.1 per cent. And even if the elastic limit were passed and the total elongation was 1 per cent, what harm could be done, since the material has a ductility of over 20 per cent?

THE AUTHOR. The aim of this paper, exclusive of the Addendum, is to furnish data for the solution of problems relating to the safety and economic design of carbonic acid containers, in so far as the physical properties of the acid itself are concerned. The data given are the results of very thorough researches on the physical properties of both chemically pure and commercial carbonic acid, and it is believed are adequate for the solution of all problems that are apt to arise in this connection.

2 The aim of the Addendum is to point out the fact that the

experimental data given in the paper cover only one phase of the cylinder problem, namely, from the standpoint of the physical properties of the carbonic acid itself; while other phases of the commercial problem, such as suitability of materials to cylinder construction, deterioration while in service, periodic heat treatment and tests, apparently have not yet been adequately investigated.

3 The author refrains from making a lengthy closure to this paper and discussions for the following reasons: First, the few questions raised on the paper proper will be clearly answered by a careful perusal of the paper itself. Second, the discussion of the Addendum relates chiefly to matters which apparently have not as yet been sufficiently investigated to enable anyone to arrive at definite conclusions. The author believes, after listening to the discussion of the Addendum, that there is still a necessity for a further investigation of the compressed-gas container problem.

FUEL ECONOMY TESTS

By C. R. Weymouth, Published in The Journal for Mid-November

Prof. W. B. Gregory. The economy shown in these tests is undoubtedly due to high boiler efficiency. Crude oil is used extensively in the southwest, especially in Louisiana and Texas, and on the Pacific coast. Boiler tests with various kinds of coal are numerous. The tests in which fuel oil was used are much more limited as some of the best work has been done by boiler manufacturers and is not available to the general public.

2 During the last seven years, the writer has made more than fifty tests with fuel oil and has had a widely varying experience with this fuel. The best results can be attained only when careful attention is given to every detail of the boiler equipment. Burners for fuel oil use from less than 3 per cent to 12 or 15 per cent of the total steam generated. The arrangement of the furnace has been found to affect results to a marked degree.

3 The greatest loss in burning fuel oil undoubtedly comes from careless manipulation of draft openings and of the damper. Much of the writer's experience has been in the testing of irrigation plants of from 50 to 600 boiler h.p. capacity where the load was constant and the efficiency in the larger plants ought to have been high. Many of the tests were made to determine the actual conditions of ordinary running without offering any suggestions as to the best way to improve economy. In a great many plants the firemen leave the draft doors wide open and so long as no smoke appears they are satisfied, never questioning whether the amount of air is greatly in excess of that required for economical results. Under these conditions, boiler efficiencies ranging from 55 to 60 per cent are to be expected and the results show that such efficiencies are obtained. On the other hand, when acceptance tests of plants were made under a fuel guarantee and care was used in finding the proper draft area, and especially in the manipulation of the damper to maintain as high a pressure as possible in the furnace and around the heating surface of the boilers, the efficiency has ranged from 73 to 75 per cent.

4 The amount of fuel saved by an intelligent control of the furnaces is therefore a large item in the annual fuel bill. This fact has not been sufficiently brought home to the operators of power plants using fuel oil. No doubt there is much to be learned regarding the control of boilers using this fuel, and there is still a wide field for research work having for its object the conserving of fuel in the form of crude oil and pointing out a few simple rules to guide the operators of such boiler plants towards a more economical generation of steam.

The Author. While the interest in this paper as evidenced by the discussion is very gratifying, it is disappointing that for purposes of comparison specific statements of economy have not been given for some of the more important Eastern and Western power stations.

2 During the last six or eight years, the steam-power central station has experienced apparently a wonderful development, and the fuel economy of these large stations is a matter of supreme importance to mechanical engineers. With modern systems for central-station records and cost-accounting, it cannot be that, privately, this subject has not received its full share of attention and study; yet, with perhaps one exception, the engineering public might search in vain the proceedings of our leading engineering societies, and even the technical press, for an authoritative statement of plant fuel economy in regular every-day service in any of these notable central stations.

3 During recent years there have been pronounced differences of engineering opinion regarding the selection of prime movers, and while these differences do not center on the question of fuel economy alone, this is, in most cases, a prime factor. It has become a custom in the selection of such apparatus to compare the steam consumption guarantees for various types at specified ratings, making reference to actual shop and plant tests as a warrant for the guarantee. It is a fact, however, that the final measure of economy is in the monthly maintained station fuel records, under actual service conditions and covering a wide range of load, rather than in shop or uniform-load tests. The engineering public are far more interested in these commercial fuel economies, than in mere statements as to steam consumption under ideal test conditions, or in speculations as to probable fuel economy based on an assumed steam economy; and in passing judgment on a matter of such importance, they are entitled to such fuel performance records.

4 The results of the official fifteen days' test of the Redondo plant were obtained on a commercial run under rapidly swaying railway load, and including all standby losses for each day during the four and one-half hour period of shutdown. It is common knowledge that there is a large discrepancy between such commercial load records and shop or uniform-load tests, a feature apparently overlooked by some members in discussing this paper.

5 The Redondo station operates in parallel with a waterpower station of about equal capacity. Practically all of the total load-variation is taken up by the Redondo engines, and as these swings correspond to those of a plant of double capacity, it follows that the rate and magnitude of load variations on each unit are about twice as great as on an ordinary or independently operated steam plant.

6 The writer has been keeping careful note of the monthly economy of the Redondo plant, in order to detect any failure, chargeable to the plant equipment, to maintain the economy as shown at the time of completion. There are external conditions—principally the intermittent failure of circulating water due to seaweed, and the operation of all or part of the plant non-condensing for intervals varying from a few hours to a few days per week—which for certain months have caused a falling off of the monthly economy by not more than from five to ten per cent.

7 But to answer properly Mr. Ennis, who apparently is under the mistaken impression that the record given was merely for a test condition, and who considers the economy stated "perhaps unprecedented if it is maintained in the ordinary operation of the plant," the writer can state that for the month of December, 1908, after seven months' operation of the Redondo station entirely under the direction of the regular plant operatives, the average economy, under similar conditions of load, etc., was even better than that obtained under the official test of the complete plant. Provided the plant upkeep is given ordinary attention, there is every reason to believe that the station will continue to maintain practically the same fuel economy; except during periods of unfavorable external conditions of the character outlined.

8 Several members have expressed the idea that compared with Eastern coal-burning plants the excellent fuel economy of the Redondo station is to be attributed wholly to the superior boiler-plant efficiency, when burning crude oil, and not to the economical performance of the prime movers, which, either by inference or conjecture, they would class as ordinary.

9 It is important to distinguish between the high efficiencies resulting from an absolutely uniform-load boiler test under ideal conditions permitting refined adjustment, and the performance under constantly changing railway load, with heavy swings and including not only a considerable period of operation at light load, but several hours of standby and radiation loss during each 24-hour period; and however good the gross boiler efficiency may be with oil fuel, there results a lower net boiler-plant efficiency, after making deductions for the steam consumption of oil burners, heating coils in oil-suction tanks, oil-pressure pumps and live-steam make-up in oil-pressure heaters, and after making the further uncertain allowances in the case of excessive moisture and sulphur in the oil, and loss by vaporization due to heating in suction tanks.

10 Judging by various general statements, there unquestionably prevails an exaggerated idea of the difference between this net boiler-plant efficiency when burning oil fuel, and when burning the best grades of anthracite and semi-bituminous coals, under the every-day commercial service conditions described, and even when using the automatic system of oil-firing. In short, the economy of this plant in view of the necessary losses in its various elements, under regular service as compared with test-conditions, indicates that not only was the boiler performance remarkably fine, as correctly indicated in the discussion, but that the individual performance of every element composing the plant was necessary of notable excellence.

11 In line with these considerations, Mr. Barrus and others have inquired for test data on the various elements of the plant. The only official tests made at Redondo are those given in the paper, and made under the control of the Testing Committee appointed by the contractor and purchaser. The only tests of individual elements were informal tests of short duration, in which the purchaser was not represented, and although they might be of service in estimating the performance to be expected in designing new plants they would not add to the value of the paper, when limited to the purpose for which it was written.

12 It seems to have been taken for granted by some that the writer is an enemy of the steam turbine, which is not so. All he desired was to bring out the fact that the piston steam engine is still an important factor in steam power plant design. On the present showing of Pacific Coast plants, he is compelled to favor the piston engine on the score of economy, but he does not wish to take a stand that either one or the other, or a combination of the two, will neces-

sarily be the most efficient, when all the elements which affect the every-day working of a power plant are considered. Under constant full-load "test conditions" the steam consumption of engines and turbines may be nearly equal, but under commercial service and on widely varying loads there may exist a marked difference in the respective fuel-economy records, and fuel economy is really "the proof of the pudding."

13 In answer to Mr. Kent—colder circulating water can be had in the East than in the West, and as the economy of the turbine depends largely on the vacuum obtainable, turbine plants installed in the West with 70-deg. circulating water will not show as favorable economy, either in steam consumption or the "coal pile," as plants in the East, where circulating water is available for a season at 35 deg. fahr., and where a vacuum of between 29 in. and 29½ in. is then obtainable.

14 Mr. Ennis states that the best records for Eastern coal-burning turbine plants are between two and two and one-half pounds of coal per kilowatt hour. If, as is probably the case, these stations are burning the best qualities of anthracite and semi-bituminous coal, then after making due correction for boiler efficiency, the Redondo station will still be ahead on the score of economy.

15 In estimating the probable economy of the Redondo engines, Mr. Ennis used a combined efficiency of engine and generator of 0.855, popularly assumed as a representative figure for steam engines, whereas that actually observed and stated in the paper is over 0.94.

16 Referring to the deduction of Mr. Bibbins, the writer again wishes to protest against theoretical considerations and calculated economies, either from prime movers to complete plants, or *vice versa.* Complete plant economy is not merely a product of engine and boiler performance, but involves many other well-known items of loss. There must be considered not only the uniform load test performance of boilers and engines at economical load, but also their poorer performance in the station on variable load, including light load and overload; and all other elements of station fuel-loss, including standby, starting and stopping, will decrease the actual every-day station economy, as compared either with the calculated full-load economy or that shown by a test of short duration. Hence, knowing the variable load economy of the complete plant, and say, the boiler efficiency, the calculated steam consumption of prime movers will be too great if these other items are neglected. Also if the boiler and engine test performance are known, the calcu-

lated complete plant economy is far too good if the other items of loss are neglected. Comparing with actual service records, Mr. Bibbins' calculation of one kilowatt-hour on fuel-consumption of 21,000 B.t.u. offers an example of the confusion resulting from such false analyses. If Mr. Bibbins and Mr. Kruesi would present to the Society some actual station fuel records, of their respective companies, either for Eastern or Western turbine plants, they would add to our store of such information, and perhaps encourage others to come forward with the same sort of data.

17 The writer's suggestion, commented on by Mr. Ennis, as to the establishment of a standard for comparison of fuel economies for power stations, had reference to the extension to complete plants of the standard set forth in the report of the committee of the British Institution of Civil Engineers, which referred only to the performance of steam engines, under different initial and final pressures and temperatures. An extract from this report is given in Ripper's The Steam Engine, Theory and Practice, p. 300. This cycle is designated by the above committee as the Rankine cycle, and is best known under this name, although previously known as the Clausius cycle.

18 The writer would emphasize the important difference in application between the standard proposed by the committee of the British Institution of Civil Engineers, and that proposed by the writer. The former refers to steam motors only, and the lower limit of temperature is that measured in the exhaust pipe near the engine. The latter refers to complete plants, including steam motor, boilers and auxiliaries, and not merely the prime mover; the lower limit is the initial temperature of circulating water and not the temperature in the exhaust pipe. The complete plant performance will depend on the efficiency of the condensing plant, and the nearness with which the vacuum approaches the lower temperature limit established by the entering circulating water.

19 Referring to Mr. Bibbins' remarks on the performance of engines at fractional loads; owing to the increasing number of expansions, and the benefits derived from the use of superheated steam, the Redondo engines actually improve, over rated economy, for a wide range of fractional load. And contrary to the prevailing opinion a good vacuum is very desirable for high engine economy, the benefit on fractional loads being especially notable. This improvement in engine economy at the lighter loads was so marked that the fractional-load losses in the remaining portions of the plant were equalized, giving for a fairly wide range of load a practically uniform fuel econ-

omy for the complete unit of engines, boilers and auxiliaries. The popular conception of the performance of the average engine on fractional load is so decidedly contrary to this, that the writer feels that he has established a significant fact in giving the curve of complete plant fuel performance.

20 To the writer's knowledge there was no consideration of increased flexibility in the inception of the four-cylinder engine, but this feature is not therefore of any less importance. The combination of the four-cylinder engine with twin condensers combines features of the utmost value, when considering the continuity of station output with a limited number of units, and also when operating in locations necessitating frequent cleaning of or tube renewals in surface condensers.

21 For the frequent special conditions at Redondo, of failure of circulating water and stoppage of condensers by seaweed, the twin-condenser arrangement is of the utmost value, permitting the cleaning of each condenser, while the entire engine exhausts to the other, thus losing between one and two inches of vacuum only. When the supply of cooling water is completely stopped by seaweed, the ability of the engines to carry the same heavy overload non-condensing, and this with high economy, is likewise a feature of great value, for on such service the effective capacity of any prime mover is its capacity when operating non-condensing.

22 Mr. O'Neil is apparently surprised, not that the actual result was so good, but that the guarantee was so poor, and he feels that this difference reflects on the ability of the engineers to determine the guarantee. This guarantee was not based on a calculated economy; it included the elements of standby loss, and variable load running, on which no data were publicly available. On the other hand, the guarantee was based on what information could be secured as to the actual performance of existing stations burning oil fuel. The contractor's initial proposal stated that the calculated economy of the complete station based on individual guarantees of apparatus, and uniform load at rating, would be 240 kw-hr. per bbl. of oil. As the existence of the Redondo station was dependent on the guaranteed cost of power, under commercial conditions of operation, its general manager later demanded a commercial load guarantee subject to a heavy penalty for failure.

23 Answering Mr. Moultrop's query as to the method of filtering cylinder oil from the feed-water, and the possible trouble from oil in the boilers, on account of the use of condensed engine exhaust as

boiler feed-water; owing to the limited supply of feed-water, it was impossible to break in the Redondo plant on raw water, and to throw the air-pump discharge overboard. An excess of cylinder oil was intentionally used in starting the engines, some of which passed by the feed-water filters and for a period caused the burning out of some of the lower row of boiler tubes. The quantity of cylinder oil was subsequently reduced so that the filters could remove enough oil to avoid difficulty with the boilers.

24 Most of the cylinder oil used by the engine is fed into the high-pressure cylinders, and this is largely eliminated by the oil separator diaphragm on entering the engine receiver, and trapped to waste. The steam entering the low-pressure cylinder is consequently comparatively free from oil. As but a small amount of cylinder oil is directly fed into the low-pressure cylinders, the total amount of oil in the condensed water is relatively small and as easily cared for by the filters. The filters are not of the pressure type, but receive water under atmospheric pressure, which passes downward through the filter by gravity. There are two filters per engine, each about 4 ft. in diameter by 5 ft. in height. In each filter are four horizontal perforated diaphragms for the support of the filtering material—usually hay—with which the filter is completely filled. The discharge pipe is so arranged as to submerge constantly all of the filtering material.

25 This general plan of filtration is in use in all Pacific Coast steam engine power plants having surface condensers, and has been successful for a period of years, although the same result does not seem to have been accomplished in Eastern power stations.

26 In view of the scarcity of accurate data as to power-plant performance, and the great difficulty of getting authentic reports tending either to prove or disprove the claims for various types of prime movers, it is to be regretted that a commission of disinterested engineers has not been appointed, to coöperate with some government bureau in obtaining complete data pertaining to the economy of all important power stations. The report of such a commission would officially stamp the correctness, or the incorrectness, of the economies claimed.

27 The writer is conversant with conditions in many Pacific Coast plants, and would be glad to coöperate with such a commission.

ARTICULATED COMPOUND LOCOMOTIVES

By C. J. Mellin. Schenectady, Published in The Journal for December

ABSTRACT OF PAPER

A locomotive articulated by the Mallet method consists principally of two sets of engines flexibly connected under one boiler, the rear, which is the high pressure engine of two cylinders, fixed rigid with the boiler and receiving the steam direct from the dome. The front or low pressure engine, also provided with two cylinders, is capable of lateral movement to adjust itself to the curvature of the road on the same general principle as a radial truck. The high-pressure engine exhausts into a receiver flexibly connecting the cylinders of the two sets of engines, from which the low pressure engine receives its steam supply and is exhausted from the latter through a flexible pipe to the stack. Each cylinder has its independent valve and gear connected to and operated with a common reversing rigging.

By this means the tractive power can be doubled over that of the ordinary engine for a given weight of rail with a substantial saving in fuel.

Mr. F. J. Cole. The type of locomotive described is singularly well adapted to a wider range of service than perhaps any other design. It was originally intended for narrow-gage roads of light construction built for military purposes, following the undulations of the country without grading, necessitating sharp curves and steep grades, in combination with light rails and the greatest economy in the construcion of track, bridges, etc. The characteristics of this design, namely, flexibility and uniform distribution of weight combined with the use of two separate engines which would not slip at the same time, rendered the design very attractive for these narrow-gage railroads.

2 The first engine of this class was built about the year 1887 and at the present time there are approximately 500 running in Europe. Some five years ago the Mallet locomotive was introduced in this country and its merits and efficiency have been recognized by railroad men wherever they have been put in service. The three articu-

lated engines designed and constructed for the Erie Railroad for use on the Susquehanna grade, of the 0880 type, are the heaviest and most powerful locomotives ever built and operated,

3 When we compare the early locomotives of this type and their work on light narrow-gage railroads, with those built last year for the Erie Railroad, where each engine took the place of three standard 100-ton consolidations, we at once appreciate the great range to which this general class of articulated locomotives is adapted. A locomotive must possess peculiar inherent qualities to enable it to perform so satisfactorily such a wide range of service, from two-foot narrow-gage roads to main line work on leading trunk lines, utilizing the extreme limits of axle loads and adhesion.

4 Some of these distinctive features are:

a Short rigid wheel base, ranging from about 2 ft. 8 in. to 14 ft. 3 in.

b Rigid connection of high-pressure steam-pipes to the rear engine, permitting steam connections between the boiler and cylinders in the ordinary way, without the use of flexible connections.

c Flexible steam connections to the low-pressure cylinders, which are easily kept tight, as a receiver pressure of only about 70 lb. has to be provided for and the packing for this pressure is not a difficult problem.

d Extreme flexibility; forward group of driving wheels, operated by low-pressure cylinders, swing freely when passing curves.

e The articulated locomotive is essentially a compound proposition presenting many advantages over the use of four simple cylinders. These engines cannot be designed as simple engines and work as satisfactorily as the present arrangement of compound cylinders, because this would necessitate the use of high-pressure flexible steam pipes and introduce other complications.

f The total weight being carried on the drivers, makes it possible to use a very high tractive power, especially valuable for pushing and helping service.

g Impossibility of both engines slipping at the same time, the receiver pressure automatically taking care of this. If the high-pressure engines commence to slip, the receiver pressure will be increased and produce greater back pressure on the high-pressure pistons, and consequently greater pressure will be admitted to the low-pressure pistons, resulting in alternating slipping from one engine to the other. This is of great value in hill climbing.

5 Considering the matter of axle-loads, this type presents many advantages because from four to eight driving axles can be employed. The limitations of the consolidation or 280 class are:

200,000 lb. on drivers, 50,000 lb. axle load
220,000 " " " 55,000 " " "
240,000 " " " 60,000 " " "

In the decapod or 2-10-0 type we have these limitations:

250,000 lb. on drivers, 50,000 lb. axle load
275,000 " " " 55,000 " " "
300,000 " " " 60,000 " " "

6 The use of 2-10-0 type, however, is very questionable except with small wheels on account of the extremely long rigid wheel base, with its necessary accompaniment of extreme flange-wear and friction in passing any but the longest radii curves. With the Mallet articulated engine a much wider range of driving wheel loads is permissible. The 0660 type permits the following loads:

300,000 lb. on drivers, 50,000 lb. axle load
330,000 " " " 55,000 " " "
360,000 " " " 60,000 " " "

The 0880 type permits the following weights on drivers:

400,000 lb. on drivers, 50,000 lb. axle load
440,000 " " " 55,000 " " "
480,000 " " " 60,000 " " "

7 The above figures show the possibilities of building locomotives of enormous tractive power larger than that possessed by any other type. The wide range of permissible axle-loads and the great flexibility, in combination with the economy produced by compounding, especially in slow service, all tend to make the design particularly well adapted to a wide range of work.

8 The ease with which these engines are fired is a matter of general surprise. This is largely due to the use of compounding, which reaches its maximum efficiency at slow speeds and long cut-offs, whereby the work of the fireman is materially reduced.

9 In ordinary service, especially for helping and pushing, the entire weight is needed for adhesion and no useful purpose is served by the additional complication of leading truck wheels. No sharp flanges have developed on the Baltimore & Ohio 0660 type after four years of service. This locomotive has been operated 24 hours per

day pushing up hill and backing down over sharp curves without detrimental effects; while the ordinary consolidations in use on this road do wear their flanges badly. This proves conclusively the extreme flexibility of this type and its ability to move freely around curves without the use of guiding wheels. The ease with which a six-wheel Pullman car truck passes around curves, presenting an almost ideal construction for this purpose, explains this freedom from flange wear. It can readily be seen that the front low-pressure engine of the Mallet locomotive of the 0660 type is really nothing more than a large six-wheel truck and it seems quite as unnecessary to add leading truck wheels to an engine of this kind for ordinary conditions as to add a leading wheel to the six-wheel car truck.

10 The sliding support carrying the weight of the boiler is located in a position to equalize wheel loads, and by swinging links between the front of the rear frames and the back of the front frames, extreme refinement can be made in the equalization of weight, so that the wheels may be equally loaded. The employment of leading or trailing truck wheels does not seem to be necessary except for the possible use in road service where speeds exceed 35 and 40 miles an hour and the boiler requirements are such as to make it impossible to utilize the entire weight of the engine for adhesive purposes. The only justification for their use seems to be in cases where the extreme boiler capacity is required. In the operation of trains at good speeds, the boiler capacity is the chief requirement and the tractive power a secondary consideration; as in the case of Atlantic or Pacific engines, where a great deal of adhesive weight is sacrificed for the purpose of obtaining greater boiler capacity.

11 Two years ago, in discussing Mr. J. E. Muhlfeld's paper on large electric and steam locomotives before the New York Railroad Club, I called attention to some advantages of this design for heavy service, among which were the following:

a Ease of turning the engine around on a "Y" of 23 deg. with no grinding of flanges and almost entire absence of flange friction, the engine appearing to pass the curves as easily as a car with the ordinary forms of trucks.

b Absence of any unusual exertion on the part of the fireman in maintaining steam pressure.

c The power reverse gear making much less made the engine very easily operated, so that much less exertion was really requiredto reverse or alter the cut-off, which involves moving four valves therein the ordinary two cylinder engine.

12 The question of guiding trucks was also considered, and the opinion which I found at that time was that their use was unnecessary and their only effect would be to complicate the design without serving any useful purpose. The two years which have elapsed since that time have merely tended to confirm this opinion and the absence of flange wear on the front driver at the present time bears testimony to the inherent flexibility of this design for use on roads having sharp curves.

Mr. Harrington Emerson. A few years ago Mr. B. J. Arnold, a prominent electrical engineer, stated that there was no known way of moving freight as cheaply as by putting a steam locomotive ahead of a train. During the last few years there has been an attempt by electrical engineers to rush the subject, and to pretend that the steam locomotive is obsolete. They proved their case by assuming ideal conditions for the installation of electric traction, assuming at the same time that current locomotive practice is the best obtainable.

2 Two things have occurred in recent times to put far into the future this electrification of all railroads. One is the panic, by which railroad managers have been reminded that it would be expensive to depreciate and make obsolete all their existing power as well as round-houses and division points: the other factor is the Mallet type of engine.

3 Before the Mallet was developed, locomotives had been lengthened out until we had for mountain grades the famous Santa Fé type, with its 34-ft. wheel bases. That locomotive operated very economically, carrying loads for less than any electric installation could possibly have carried them.

4 I remember a discussion between a former superintendent of motive power, and the general manager of the Santa Fé system, in which the latter accused the superintendent's locomotive of spreading the track so that nothing could run over it. The superintendent replied that it was the business of the general manager to keep the track in order. The question of the wheel base, which was the limiting question in the old type of locomotive, is obviated in the Mallet type, so that for many years the Mallet will be found operating with the highest economy on mountain grades.

5 There is a difficulty with the Mallet that was also experienced with the Santa Fé type. I was once with the superintendent when he received a telegram that one of the locomotives was off the track.

He wired to find what speed she was running at, and the reply came that the locomotive was not running at all, but was standing still. The superintendent remarked, "We are up against it when locomotives jump the track when standing still." That difficulty may also be experienced from the heavy weight of the Mallet on drivers.

Mr. L. R. Pomeroy. The paper and discussion thus far have been confined mainly to questions of design and construction. The speaker desires to call attention briefly, to some of the commercial advantages of the Mallet type.

2 Generally speaking, the gain to be expected, from the substitution of electric for steam operation, depends greatly on the density of traffic coupled with the frequency of units. And further, if it is not possible to accomplish by electric service something now impossible with steam service, then the adoption of electric service is not commercially practical, for there is nothing to be gained, *per se,* by the mere substitution of one kind of power for another.

3 This at once suggests the question of capacity. On certain mountain grades where the maintenance of expensive helper service is necessary, about all that can be figured out in favor of electric haulage, owing to the limited volume of business in the particular case, would be that the tonnage per train on a given grade or section could be nearly doubled, or the train mileage halved, without a corresponding increase in train-crew expense.

4 For instance, a 50-mile mountain section having a maximum grade of 2.2 per cent, with seven trains per day in each direction. The reduction of one-half in train mileage with the same tonnage at 50 cents per train mile, the rate covering the items directly affected as used in computing the saving or advantages in grade reduction, would amount to $65,000 per annum, and this amount capitalized at 6 per cent would equal about $1,000,000. But to obtain this saving electrically the complete electric apparatus would probably cost considerably more than this capitalized amount, whereas the requisite number of Mallet compound steam locomotives to perform the service would cost about one-third of the amount necessary for an equivalent electric service.

5 To state the case another way, i.e., based on train-crew saving only, leaving out entirely all other advantages. The total of 14 trains is the equivalent of about 700 train miles per day and the cost for

train crews amounts to from 12½ to 15 cents per train mile. Then the saving per annum will be

$$\frac{700 \times 0.14 \times 365}{2} = \$17,800$$

This amount capitalized at 6 per cent equals about $300,000, or more than enough to pay for the required number of Mallet locomotives to perform the service.

6 The foregoing is not meant to be a reflection on electric possibilities, *per se*. The particular case cited does not possess the inherent magnitude of business to warrant or justify an electric proposition, but it does show that until future conditions change there are a great many cases where the Mallet type of locomotive will serve as a profitable bridge over the deep chasm between present conditions and the eventual supremacy of the electric locomotive.

Mr. George L. Fowler. As I was coming up the stairs a few moments ago I met Professor Goss, who was about to leave the building, and he asked me to say a word for him. He wanted me to call attention to the fact that when Mallet designed his locomotive, it was designed for narrow gage roads, and for comparatively light traffic, as has already been mentioned in the discussion, and when an attempt was made to apply this principle to the tremendously heavy locomotives required for American service, such as we have in the Great Northern, Baltimore & Ohio and Erie engines, the problem assumed a magnitude which Mallet probably did not consider when he first designed his engine, so that in taking that principle and adapting it to the heavy locomotives of American practice, great merit must be given to the designer of the first heavy Mallet engine in this country, the gentleman who presented the paper to you this afternoon, Mr. Mellin. This is for Professor Goss.

Mr. George R. Henderson. The only thing I want to note is the necessity in these large engines for a pretty liberal supply of fuel, and possibly a liberal supply of men to put it in, unless we use liquid fuel, or have some mechanical means of putting coal in the fire-boxes. Take one of the Mallet engines with 80,000 lb. tractive force, and attempt to use that force at a speed of anywhere near 15 miles an hour; a large amount of coal, five tons, or 10,000 lb., an hour, would be called for in the fire-box, and I think it is time for those interested in mechanical stokers to suggest a practical means of supplying this fuel to the engines, so that they may not merely pull cars at slow speed, but give a fairly good return in horse power developed for money invested.

Mr. Alfred Lovell. The Mallet articulated locomotive presents an opportunity to utilize steam by double expansion without increasing the number of working-parts over those required for single-expansion engines of corresponding weight and power, and to increase further the economy thus secured, by the introduction of superheating; an advantage touched upon only lightly by the author, and deserving of a more complete recognition.

2 The key-note of present-day engineering thought and activity is the conservation of resources, as was impressed upon us by the valuable address of the President of the Society at the opening of the December meeting.

3 In this address it is stated that under the best conditions that prevail in stationary power plants not more than 15 per cent of the heat value of the coal used is utilized in actual work produced at the engine, and that under average conditions a considerably smaller percentage is realized. The best conditions referred to evidently contemplate the multiple expansion principle in the use of steam. In the best locomotive practice the conditions are still less advantageous for the utilization of the heat value of fuel, and in average locomotive service the percentage is probably much less than in average stationary plants. In the locomotive tests at the St. Louis Exposition in 1904, the work at the draw bar, not including engine friction, represented a percentage of the heat value of the coal ranging from about $3\frac{4}{10}$ per cent in simple engines at high speed, to about $8\frac{6}{10}$ per cent in the best compound engines at low speed.

4 Good engineering practice thus demands that locomotives be so designed as to increase to a maximum the utilization of the heat of the fuel, and without excessive complication that might result in excessive maintenance cost, or delays to service.

5 In Europe the advantage of double expansion in locomotive practice has long been recognized. In American railway service, the last twenty years have demonstrated absolutely that the compound use of steam in locomotive service results in a substantial saving of fuel, the percentage ranging from 5 to 40 per cent, according to the character and conditions of service. It has also been demonstrated that in long continued service, covering several years,

boiler repairs are less with the compound, due to less demand for steam and milder exhaust.

6 When the compound locomotive was first built with four cylinders and their complement of pistons, piston rods, and rod and valve packing it was found that notwithstanding the decreased boiler wear, the liability to disorder from breakage or wear of engine parts, on account of the slightly increased number of wearing parts, sometimes quite offset the advantage of fuel economy. The cross compound or two-cylinder type, high-pressure on one side and low-pressure on the other, was expected to overcome this objection, and these were built in considerable numbers for several years succeeding 1895.

7 Experience proved that under certain conditions this latter type developed unequal or twisting strains in the opposite sides, sometimes resulting in breakage of frames and other parts. Moreover, the demand for increased size of units of power soon brought the low pressure cylinder in the two-cylinder compound to the limit of size permissible. The result was a further development of four-cylinder compounds, and the tandem and balanced compound types were produced.

8 Both of these types are good fuel savers, and are free from some of the objectionable features of the earlier types, while the tandem gives opportunity to construct units of great size and power. Yet the slightly greater number of working parts, and the anticipated or actual difficulty of reaching some of these parts in making running repairs, cause many to reject them and to perpetuate the wasteful method of using the steam single expansively.

9 The articulated compound locomotive bids fair to overcome these objections entirely. This locomotive is in effect two engines with one large boiler and one fire-box. The two engines together use the steam double expansively, and with no more cylinders and working parts than two single-expansion engines. Boiler repairs should be relatively small since the minimum of steam is required and the exhaust is mild. Wearing parts of engines are easily accessible.

10 One engineer operates both engines as readily as one four-cylinder engine. Owing to the economical use of steam, one fireman can stoke a locomotive of this type having very large tractive power. The type thus provides means for the economical use of fuel with a minimum of labor and no increase of disorder delays, or in engine repair cost, and with a probable reduction in boiler repair

cost as compared with single-expansion locomotives of corresponding power.

11 Superheating of steam in locomotive practice has been shown to effect fuel economies in single-expansion locomotives nearly or quite equal to those secured by compounding. It is probable that with proper arrangements a combination of double-expansion, and of superheating the steam before using, or reheating it between the high and low pressure cylinders, will give greater fuel economy than either compounding or superheating alone. The flexibility of arrangement possible in this type of locomotive presents a most advantageous opportunity for this combination.

12 The necessities of the future will demand in locomotive practice the greatest possible conservation of skilled labor and of fuel, and for the reasons mentioned the Mallet articulated compound locomotive is worthy of the spirit of the day, and will perform an important part in the economies of the future.

Mr. S. M. Vauclain exhibited a large number of lantern slides of which he gave an interesting running account by way of discussion of the paper. These related to the initial work of Mallet in the development of the type of locomotive that bears his name and to locomotives of this type built by the Baldwin Locomotive Works. He said: "It is not my purpose to criticise the admirable paper of Mr. Mellin; but merely to preface my discussion with remarks to the effect that I do not coincide with the author in all his conclusions or in his treatment of the principles upon which Mr. Mallet has spent so many years of his most useful career. One design of this most flexible type of locomotive may be so treated as to include many devices considered entirely unnecessary by the inventor, yet on the other hand it is quite natural to make additions or changes common to American practice and suggested by years of experience on American roads. It is not my purpose to discuss the details of the paper but to add what is most lacking, a historical sketch giving the fullest honor to the original inventor, and to show the development of the subject in the United States from the standpoint of our progressive railroad men.

2 "It was Mallet who, in 1875, started the era of economics in locomotive building destined to keep all minor lights in locomotive building fully occupied. He did this by means of a two-cylinder or cross-compound locomotive of Roentgen type built at Creusot for the Bayonne & Biarritz Railway. In 1877 he recognized the ineffi-

ciency of this type, since proved in America, and adopted the more sensible four-cylinder tandem type. But so rapidly did his mind work that during the same year he changed from the tandem type to one in which the cylinders were coupled to separate systems of wheels and operated independently, but with one supply of steam. His idea was either to use a rigid frame or to articulate. The De-Glehm engines, the first of which was built in 1885 for the *Chemin de Fer du Nord* and later for the Paris, Lyons & Mediterranean, were of the former or solid-frame pattern. He shortly thereafter successfully introduced the articulated frame which is considered a characteristic feature of the type which now bears his name, and we owe to Mr. Mallet all the honor that may ensue from its introduction in this country. It is to be regretted that, like Walschaerts, Mallet is unable to realize the full benefit of his inventions, owing to the time limit of the patent law.

3 "The Baldwin Locomotive Works recognized the merit of Mallet's invention and in 1889 made a careful investigation of the engine used by the Decauville Railway at the Paris Exposition. Numerous efforts were made to interest both foreign and domestic railroads, and Mr. Mallet personally assisted in planning the general types. The first design for a domestic road was submitted to the Erie Railroad in 1898, and it was at that time considered a very heavy locomotive.

4 Many designs were worked out for J. W. Kendrick, Second Vice-President of the Atchison, Topeka & Santa Fe Railway. The later designs of this series had an intermediate chamber to overcome the objectionable length of tubes, fire-box combustion chamber, and leading and trailing trucks. In one of the designs for passenger service it was intended to produce a locomotive, with superheater, of sufficient power for the heaviest train on grades of two per cent and less.

5 The design finally proposed by Mr. Kendrick had a reheater between the high and low pressure cylinders through which the steam must pass on the way to the low-pressure engine, and also a feed-water heater. The cylinders in this engine face each other as in previous design for freight service.

6 Designs were proposed for freight service, embodying the jointed boiler feature having cylinders facing each other, open combustion chamber covered by a movable cap, etc. The design finally adopted for freight service for this railroad had a reheater, superheater and feed-water heater, and a detachable front section making

all parts readily accessible. The final type agreed upon for passenger service has five pairs of driving wheels, a four-wheel leading truck and a two-wheel trailing truck.

7 One of the first to recognize the merit of the Mallet type of locomotive was J. J. Hill, who ordered five of these locomotives. A design of a locomotive without a truck was first submitted, but he demanded a trailing, as well as a leading, truck, and experience with this arrangement has proven his diversion from previous practice to be justified. This was also in accordance with our own preference.

8 On the Great Northern Railway, 67 engines of the Mallet type are now in use working on grades of from 0.6 per cent to 2.2 per cent. The speaker had received from Geo. H. Emerson, Superintendent of Motive Power of this road, data upon the performance of some of these engines, which he submitted in abstract. These are given in full under Mr. Emerson's name in the discussion immediately following.

9 Engines designed for service on the Mexican Central were then referred to, and a résumé was given of designs proposed for the Southern Pacific and worked out at the solicitation of J. Kruttschnitt. The first design had no trucks, no tender side tanks being employed. The side tanks, however, reduced the boiler capacity and the coal box was inadequate. The second design provided for separate cabs for the engineer and the fireman. The engineer was placed forward and the fireman in the rear. A combustion chamber was employed in the third design in order to reduce the length of flues to a reasonable figure. The fourth design was made to overcome the objection of small driving wheels; in it were employed all the possible details of the Harriman common standards. This design shows a logical outcome, and two locomotives of the type are now in the course of construction. The low-pressure cylinders are detachable, the boiler is separable and the steam from the high to the low pressure cylinders passes through a Vauclain reheater.

10 In closing, the speaker referred to a special design of his own, differing from that of the Mallet type previously noted, in having a flexible boiler instead of provision for sliding contact for the front end of the boiler to the supporting member of the frame, providing the necessary lateral movement in rounding curves. The boiler is in two sections, each firmly secured to its own cylinders, and frames hinged after the Mallet design, but the two sections of the boiler joined by a flexible connection between the two smoke chambers containing the superheater and the reheater.

Mr. G. H. Emerson. In October 1906 the Great Northern Railway received five large Mallet engines, the two high-pressure cylinders being 21½ in. in diameter by 32 in. stroke, the two low-pressure cylinders located on forward engine 33 in. in diameter by 32 in. stroke: boiler pressure 200 lb.; weight on drivers 316,000 lb.; total weight of engine and tender loaded 503,200 lb.; diameter of drivers 55 in.; engine having two-wheel pony truck, three pairs of drivers on front engine with three pairs of drivers followed by two-wheel trailer on rear engine; boiler having total heating surface of 5700 sq. ft. and grate area of 78 sq. ft.; maximum rigid wheel base on either engine, 10 ft. This engine will be referred to hereafter as class L-1.

2 The largest engines heretofore used by this company were the consolidation F-class having cylinders 20 by 32; carrying 210 lb. boiler pressure; 180,000 lb. on driver; total weight of engine and tender 318,000 lb.; total heating surface of boiler 2768.4; total grate area 59.2; diameter of drivers 55 in.

3 The five large class L-1 Mallets above referred to were purchased as helpers on heavy grades and were placed in service on the Cascade Mountains between Skykomish and Leavenworth, where the ruling grade is 2.2 per cent. East from Skykomish there are 22 miles of continuous 2.2 per cent grade with a let-up through the Cascade Tunnel of 1.7 for a distance of three miles. West from Leavenworth there is almost a continuous grade of 2.2 per cent for a distance of 32 miles ending at Cascade Tunnel station. The engines were put to work on this hill in helper service to take the place of the consolidation F-8 type as pusher and to help an F-8 engine used in road service between Leavenworth and Delta, a distance of 109 miles.

4 The engines were so large they could not be taken care of with the facilities provided. As they could not be turned around without providing further facilities, they were designed with pony truck in front and trailer behind and during the first winter's service, therefore, they were not turned nor were they taken into a roundhouse.

5 Soon after receiving these engines tests were made to determine the tonnage which they could handle, and their economy as compared with the consolidation engine. One L-1 was first used as a helper engine with an F-8 as a road engine and it was found that the two engines could easily handle 1300 tons up the mountain. It was further developed that while the F-8 handled only 500 the L-1 handled 800 tons of the train, using no more coal with this load, and in fact somewhat less, than the consolidation with her part of the train.

6 The first winter's performance was so favorable to the Mallet engine, both from an operating and a maintenance standpoint, that arrangements were made for additional Mallets, as it had been decided they could be used in road service as well as on hill service, and in May 1907 25 road Mallets were received, somewhat smaller than the first ones purchased, their high-pressure cylinders being 20 by 30; low pressure 31 by 30, 200 lb. boiler pressure; 250,000 lb. on drivers; total weight of tender and engine 451,000; total heating surface 3914; grate area 53.4 sq. ft. The general design of this engine was the same as that of the former one, except that it was of smaller dimensions, and the boiler provided on the engine was identical with the boiler used on Prairie and Pacific engines having cylinders 22 by 30 with 69-in. drivers, carrying 210 lb. steam pressure. This last or road class will hereafter be designated as L-2.

7 These engines were put in service on a section of the road where there is a 1 per cent grade and showed themselves so economical that in May 1908 further Mallet engines were received as follows: 17 type L-1 and 20 type L-2, it having been decided to extend the use of the Mallet engines to districts having grades as low as 0.72 per cent.

PERFORMANCE ON CASCADE DIVISION

8 Distance from Leavenworth to Everett, 108.70 miles; ruling grade, both directions, 2.2 per cent; total ascent: west, 2192, east, 3376.

9 On the main line of the Cascade Division between Leavenworth and Everett, the Mallet class L-1 engine has superseded the consolidation F-8 class. As explained in Par. 3, the large Mallets were first introduced on the hill between Skykomish and Leavenworth with consolidation train engine and L-1 helpers used on the hill only. Up to the present time the tonnage taken over this mountain has been gradually increased from 1050, with two consolidation engines, to 1600 tons now being hauled with L-1 engines. The L-1 engines have replaced the consolidation engines and it is now the practice to start out from Everett with one L-1 engine used as a road engine taking 1600 tons as far as Skykomish over a ruling grade of one per cent. At Skykomish another L-1 is put on as a pusher and the two engines take the 1600-ton train over the mountain. The tonnage hauled in the opposite direction is the same and the L-1 or large Mallet helper has proved herself not only worthy of helper service, but a good reliable road engine, and the combination of road and helper service

works out admirably on this division, making it unnecessary going east to reduce the tonnage at Skykomish in order to get over the heavy grade.

10 Recent performance shows that on a round trip over this division the L-1 engines handled 1600 tons with a total of $43\frac{5}{6}$ tons of coal or equivalent to 25.13 lb. of coal per 100-ton mile. The F-8 consolidation type could handle only a 1050-ton train, with practically the same amount of coal, or equivalent to 38.29 lb. of coal per 100-ton mile. In other words, the tonnage on this division has been increased at least 52 per cent with a saving of 34.39 per cent lb. of coal per 100-ton mile, due to the Mallet engine. The pusher engines on this district are allowed only switching mileage, that is, 6 miles per hour while in actual service, and for this reason it is somewhat hard to make a comparison with other engines, as they will take the 1600-ton train over the mountain on the hardest pull at a speed of not less than 8 miles per hour.

11 A good showing in repairs is made by the average of 22.33 cents per mile for the year ending June 30, 1908, especially when it is considered that during this period the engines were exclusively in pusher service. Since putting L-1 large Mallets in road service to replace all the consolidation type, the performance has been so satisfactory that only four are now used as pushers exclusively, two as helpers over the Cascade mountains and two on the Butte Division in transfer service.

PERFORMANCE ON SPOKANE DIVISION

12 Distance from Spokane to Leavenworth: 197.40 miles; ruling grade, both directions, 1.0 per cent; total ascent: west, 1351, east 2186.

13 The 1600 tons delivered from Cascade Division at Leavenworth are here reduced to 1450. A small Mallet L-2 takes this train to Hillyard, a distance of about 202 miles. Here too the hauling capacity of the Mallet engine has made possible an increase in tonnage from 1100 tons hauled by the consolidation to 1450 tons, an increase of 31.8 per cent. The run is so long that this tonnage of 1450 has been established by this division in order to get trains over the district in a reasonable time. Engines have not been loaded down to mere drags, but the L-2 Mallet engine handles this tonnage, from 8 to 10 miles per hour on the heaviest hills, up to 30 miles per hour over portions of the district where the grade is not so hard.

The performance for the year ending June 30, 1908, shows 22.04 lb. of coal per 100-ton mile on this district, a saving of 27.5 per cent over a consolidation.

PERFORMANCE ON KALISPELL DIVISION

14 Distance from Cutbank to Whitefish, 127.88 miles: ruling grade: west, 1.0, east, 1.8 per cent; total ascent: west 1613, east 2305.

15 On the Kalispell Division, which is the next division east where Mallet engines are used, the L-2 engine takes a train of 1700 tons from Whitefish to Essex, where the ruling grade is 0.8 per cent. At Essex a large L-1 helper is put on to help the train up to Summit, a distance of 18 miles, where the ruling grade is 1.8 per cent. West bound, L-2 engine takes a train of 1450 tons from Cutbank to Whitefish, ruling grade being 1 per cent. On this district replacement of the F-9 class consolidation by the Mallet engine has increased the tonnage 20 per cent with a corresponding reduction in coal per 100-ton mile of 20.7 per cent.

PERFORMANCE ON MONTANA DIVISION

16 Distance from Havre to Cutbank, 129.37 miles; ruling grade: west 1.0, east 0.8; total ascent: west 1952, east 712.

17 From Cutbank to Havre, another L-2 Mallet engine carries through the 1700 tons delivered from the Kalispell Division. Going west from Havre, the L-2 road Mallet handles 1450 tons. The round trip on this division with L-2 engine is made with 32 tons of coal, or equivalent to 15.75 lb. of coal per 100-ton mile. F-7 consolidation previously used, requiring the same amount of coal, handled only 1200 tons west and 1425 east, or equivalent to 18.9 lb. of coal per 100-ton mile, showing a decrease by the use of the Mallet engine of 16.6 per cent of coal per 100-ton mile, and an increase of 20 per cent tonnage.

PERFORMANCE ON MINOT DIVISION

18 Distance from Minot to Williston, 120.83 miles; ruling grade both directions, 0.72 per cent; total ascent: west 1069.7, east 777.1.

19 Here the L-2 small Mallet has replaced the F-8 consolidation, having increased tonnage from 1600 to 2200. The L-2 engine makes the round trip on 30 tons of coal, or equivalent to 11.29 lb. of coal per 100-ton mile as against 15.49 lb. of coal per 100-ton mile for consoli-

dation, having increased tonnage 37.5 per cent with performance of 27 per cent less coal per 100-ton mile.

PERFORMANCE ON BUTTE DIVISION

21 There are now two L-1 engines in transfer service between Butte and Woodville, where the ruling grade is 2.2 per cent. Their performance compares very favorably with that on the Cascade Division.

22 The L-2 engines have done good road service between Clancy and Woodville, on this division, replacing the F-8 engines where the tonnage was increased from 550 to 700 tons going west over a 2.2 per cent grade and from 1200 to 1650 going east. Owing, however, to another part of this branch having been washed out in the early summer, and track conditions not allowing for the handling of heavy trains east of Clancy, the Mallet engines between Clancy and Woodville were taken to other divisions until such time as the handling of heavy trains on this district would be warranted. The two Mallets in transfer service between Butte and Woodville, however, are still retained in service and are doing business formerly done by five consolidations.

GENERAL

23 The performance of Mallet engines above referred to by divisions shows their economy in fuel, also how they have increased the tonnage per train and thus cut down the cost of train service, as it may be said that two trains with Mallet engines have replaced three trains hauled with consolidations.

24 The cost of maintenance one would naturally expect to be higher on the Mallet engines, but for the year ending June 30, 1908, the cost of repairs on the L-2 road engines was 10.47 cents, which we do not think at all excessive when it is considered that we have two pairs of cylinders and two engines but only one boiler to maintain. The cost of maintenance on consolidation engines in the same service is very seldom less than eight cents per mile.

25 Another feature which has been noticed from the start is that the Mallet engine is not at all hard on draw bars, principally because it is not possible in starting a train to slip both sets of drivers at the same time, so that the train is not jerked as it would be by a simple engine slipping and catching. When the Mallet engine does slip it is usually the high-pressure engine which slips first. This naturally builds up the receiver pressure and will cause the low-pressure engine

to slip until the receiver pressure is worked down and the engines get down to equal work.

26 The tire-wear on these engines is very light and the flange-wear is also not excessive. In fact, Mallet engines have been put in on some districts where the flanges on consolidations would cut badly, and no appreciable flange wear has been noticed on the Mallets, no doubt on account of the short rigid wheel-base as well as the guiding pony truck. It is hardly necessary to state that the Mallet engine with its rigid wheel base of only 10 ft. and axle load not to exceed 50,000 is not hard on the track.

27 We still have in service two of the first L-1 Mallet engines, which have never yet been in the shop for general overhauling, in fact, have never been off their wheels, but have been in continual service since October 1906, with the exception of light roundhouse repairs. The above performance would seem somewhat exaggerated, in fact the correctness of these statements has very naturally been questioned on several occasions by motive power officials not acquainted with the Mallet engines. Fortunately, however, some of them have had the privilege of investigating for themselves and I think it can be fairly stated that no one who has seen them in operation has been disappointed with their performance. While not wishing to say anything to retard the progress of the electric locomotive, we cannot help feeling that the introduction of the Mallet engine has set back the introduction of the electric locomotive for a great deal of hill service, as the Mallet performance has set a new figure for economical performance.

The Author. It seems from the discussion that the only point of difference in opinion is whether a truck should be used or not. Its necessity cannot be proved by simply putting it there, but by omitting it, and the numerous cases of observation of engines properly designed with the omission of the truck prove conclusively that it is not required, and have in every way borne out the argument made in the paper for its omission. If a railroad, however, insists on having the truck and carries the responsibility for the service of the engine, it will of course have to be applied, but they would do better to leave it off, as it necessarily reduces the efficiency of the engine by its added resistance.

2 Mr. Vauclain said that European builders have applied the trucks on this type of engine, but so far as this is done it has generally been confined to engines with only two pairs of driving wheels in

each set of engines, and where the curvatures have been so sharp that so short a wheel has been considered insufficient for the safe guiding of the engine, or in some cases where the builders and the roads ordering such engines have been in doubt as to their qualifications and have therefore added the trucks as a safeguard.

3 The oldest and most successful users and builders of this type of engine do not apply the truck, with an occasional exception of the two-axle class referred to above.

4 I heard with pleasure Mr. Vauclain's high tribute to Mr. Mallet, in which I join most heartily and hope that he may live to see his labor fully recognized, which is seldom the case with the prominent men who are in advance of their contemporaries. In regard to the cross-compound engine, however, Mr. Vauclain's statement that it has proved to be on a wrong principle will need some modification, so far as this continent is concerned. There are cross-compound locomotives in use which have shown for years a saving in fuel of from 25 to 40 per cent from the start to the present day. One of the greater trunk lines has for the last ten years built this type of engine exclusively, for its heaviest freight service, amounting to several hundred engines, and has found by frequent and thorough tests (the latest within the last few months) that performances are as good today as they were ten years ago, these engines hauling 45 per cent more load than the simple engines, to the same amount of fuel. They find them also considerably easier on repairs, using one set of tubes, to two sets on the corresponding simple engine, and they make 20 to 30 per cent more mileage between the repairs. These facts can be verified by anyone interested, by personal inspection, as they are in service every day, and I have no doubt but that the officials of the road will give any desired information about them.

5 The continuously increasing weight of the locomotive in general necessitated the compound to follow, and when 220 000-lb. engines were required, the size of the L. P. cylinder became too large for the limited clearances on most roads; the articulated type of engine described is simply an outgrowth or duplication thereof in all its essential features and advantages, with the adoption of the Mallet principle of articulation. With the expectation that the discussion would bring forth some particulars as to the performance of this engine, reference to it was purposely omitted from the text of the paper, and a few points of comparison with the 100-ton simple engines used in the same service may be of interest.

6 In pushing-work it took the place of two of these engines and

did the work with ease. Special attempts were made to stall it by shutting off the front engine on the heaviest grade under full load, based on the capacity of three of the other engines, but it pushed both train and front engine to the top of the grade.

7 In road service it is rated to 2400 tons over a given division where two of the 100-ton simple engines are rated to 2200 tons (double headers), consuming practically the same amount of fuel as one of the simple engines. In order to find out the maximum power of the engine it was decided to make up a train of 2700 tons weight, but this did not stall the engine and another train of 2900 tons was tried with the same result; apparently no further attempt to stall her by overload has been made.

8 Another engine of this particular type and practically the same size has shown fully as good results in an entirely different kind of service, namely, pushing a snow-plow, where its extreme power at slow speed comes in most advantageously. Under these conditions it has successfully handled the snow-plow alone where the ordinary engine will stall and where it formerly required five 100-ton engines to do this work on various occasions.

9 One of the Erie engines, referred to by Mr. Cole, on one occasion started a train of four ordinary engine loads and the front engine on the grade, after having fixed a broken air hose.

10 These facts prove the statement in Par. 52 that, due to extreme power in running slow, the starting is affected without jerks and shocks, making it less destructive on cars and couplers than with much lighter ordinary engines that always have to jerk their trains into motion, utilizing whatever slack can be had in couplers.

THE SURGE TANK IN WATER POWER PLANTS

By Raymond D. Johnson, Published in June (1908) Proceedings

ADDITION TO AUTHOR'S CLOSURE

20 Time has been found for a careful study of the error in Equation 7 as indicated by Mr. Larner's figures, Table 2. The error made by substituting $V'_{\max}$ for V_2 in Equation 7 cannot be correctly expressed by a single figure, because one assumes, in an actual case, all the conditions except the value of R, which is computed from the other accepted figures. Both $V'_{\max}$ and $Y_{\max}$ are therefore assumed, as well as the intended per cent load change.

21 As a matter of fact, the value of R thus deduced is never such as to permit a realization of the accepted $Y_{\max}$ simultaneously with the corresponding value assumed for $V'_{\max}$. In other words, when V' actually reaches a value equal to that predetermined as a maximum, a certain small excess load above that contemplated must have been demanded, as shown in Column 1 in the table herewith. (The assumed load change has been reduced to 10 per cent in all cases, for ease of comparison.) The value of $Y_{\max}$ existing at that time would, however, be a little *less* than the intended value, so that, if an extraordinary load, greater even than shown in Column 1, should be demanded, thus incidentally *increasing* the value of $V'_{\max}$ *above the estimated figure,* the tank would still be large enough to permit a load change equal to that shown in Column 2, in which case the tank would theoretically become empty.

22 Inasmuch as the value fixed for $V'_{\max}$ is very important (because it is a rough index of the *length of life* of the wave) one is led to regard the values in Column 1 as more properly expressing the capacity of the tank than the values in Column 2. It is apparent, at any rate, that two values are required for a full appreciation of the amount of excess which is provided. The figures indicate the percentage of increase above the *existing load,* as compared, in all cases, with an estimated 10 per cent increment. The table is made up by faithful adherence to Mr. Larner's figures.

23 Example 12 seems to be an illustration of an augmenting wave, and if so, the tabulated errors are naturally meaningless. I have, therefore, been obliged to omit it as valueless in this connection.

24 It has been my experience that any error creeping in through the arithmetic integration is often on the *unsafe side,* and hence one may expect that in some instances, at least, the tabulated excess is greater than that actually provided by Equation 7. I am led to question the usefulness of the values given by Mr. Larner in the last examples because an inspection of the various quantities which he has worked out indicates that the design provided by them would be inadequate on account of a very long-lived wave.

TABLE 4 LOCAL CHANGES PROVIDED BY EQUATION 7

Compared with an Estimated 10 Per Cent Change for Mr. Larner's 15 Examples

Example No.	Column 1	Column 2
1	10.86	12.42 (?)
2	10.71	11.53
3	10.10	10.42
4	10.20	10.86
5	10.41	11.25
6	10.28	11.05
7	10.30	10.92
8	10.27	10.73
9	10.20	10.72
10	11.62 (?)	13.10 (?)
11	10.08	10.74
13	10.72	11.76
14	11.83 (?)	13.00 (?)
15	12.00 (?)	12.81 (?)

SAFETY VALVE DISCUSSION

CONTINUED FROM THE FEBRUARY MEETING

Prof. F. L. Pryor. The results secured from tests made by the writer some time ago, in conjunction with Professor Jacobus, to obtain the blowing-off pressure of safety valves when tested with water and with steam, may be interesting to the Society.

2 For the purpose of the determination, a standard 4-in. pop safety valve, set for 125 lb., was mounted on a 4-in. pipe and so connected that either steam pressure or water pressure could be admitted to the valve. In all the tests the pressure required to open the valve was determined by subjecting it alternately to steam and water pressure, the setting of the valve being the same for the steam and the water in each pair of tests. The water was at a temperature of 100 deg. fahr.

3 One set of tests was made over a period of 15 days, the test of one day being with steam and the following day with water, and so on until the series was completed. The lapse of time between tests was allowed to insure that the valve had obtained its normal condition of temperature, etc.

4 In a second series of tests the valve was tested at three different settings on the same day, viz. 104, 131 and 159 lb., the spring and valve being, in each case, cooled in cold water before taking the measurement for the water-pressure test.

5 The third series of tests was made with the valve at a number of different settings, from 105 to 165 lb., one measurement being made directly after the other and no precaution taken to insure that the valve had returned to its normal temperature after the preceding test, except that before operating with water pressure a considerable amount of water was flushed through the valve.

6 The results obtained in all the tests were in practical agreement, and indicated that the blowing-off pressure with steam and with water did not differ to any great extent, although the pressure to blow off with water was higher than with steam.

7 In the case when the valve was allowed to cool 24 hours, the water pressure required to open it was about 3½ lb. higher than the

steam pressure. In the tests where the valve was cooled thoroughly with water, the pressure with water was about 3 lb. higher than with steam. In the rapid change test the water pressure amounted to about 2.6 lb. more than the steam pressure.

8 In all tests the steam and water pressure record was that at which the valve was in full operation. In the case of the steam pressure test there were two distinct points below full open pressure which could also have been noted: when the valve began to leak, which occurred about 2 lb. below the final blowing-off pressure, and when the rate of flow suddenly increased, which was about 1 lb. below maximum.

Prof. Edw. F. Miller. The weight of steam to be discharged through a locomotive safety valve need be only a small proportion of the steam generated by the boiler, as Mr. Whyte has said. In the case of stationary boilers, however, the safety valves must be able to take care of the entire capacity of the boiler. The sudden closing of the safety throttle on an engine or a turbine by instantly stopping the demand for steam compels the safety valves to discharge for a time at least as much steam as the boilers were generating at the instant the throttle closed. The writer has seen the pressure go up on account of insufficient safety valve discharge, 15 lb. above the blowing pressure of the valves.

2 The writer believes that the correct way to figure a safety valve is to make the discharge area of the valve or valves sufficient to handle all the steam the boiler can make at its maximum rate of coal consumption; which amounts to making the size of the safety valve depend on the grate area, the weight of coal burned per square foot of grate per hour and the evaporation per pound of coal burned.

3 The weight of steam flowing through an orifice with a slightly rounded entrance may be figured quite accurately by Napier's formula (sometimes called Rankine's formula). Its accuracy for commercially dry steam has been shown by tests made under pressures varying from 30 to 150 lb. There are a number of papers on this subject in the earlier volumes of the Transactions. According to the formula the weight of steam discharged per second through an orifice with slightly rounded entrance is $\frac{F\,P}{70}$, where F is the area of the orifice in square inches and P is the pressure in pounds absolute on one square inch.

4 The discharge per second through an orifice with sharp edge at entrance, as would be the case in a safety valve, has been found from actual tests on values to be 0.95 the amount figured from this formula.

5 The opening needed in a safety valve may be figured as follows:

G = grate area.
R = rate of coal consumption per square foot of grate per hour.
9 = probable evaporation per pound of coal under actual conditions.

$$\frac{G \times R \times 9}{3600} = \text{weight of steam made per second.}$$

Equate this to the preceding expression and solve for F:

$$\frac{G \times R \times 9}{3600} = 0.95\,\frac{F \times P}{70}$$

$$F = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95}$$

6 The area of the opening through a safety valve is equal to the inner circumference of the seat times the effective lift. For a valve with seat at an angle the effective lift is equal to the lift multiplied by the cosine of the angle the seat makes with a horizontal.

7 For a 45-deg. angle the effective lift is 0.707 × lift. Calling D the inner diameter of the valve, the opening is

$$\pi \times D \times \text{lift} \times 0.707$$

Substituting this for F,

$$\pi D \times \text{lift} \times 0.707 = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95}$$

If the lift of the valve is $\frac{1}{10}$ in.,

$$D = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95 \times \pi \times 0.707 \times 0.1} = \frac{G\,R}{P \times 1.206}$$

If the lift is 0.05 instead of 0.10, then the value dia. D is doubled. Doubling the pressure will make the same valve with same lift take care of double the weight of steam.

8 For illustration:

Grate area = 25.
Coal consumption = 18 lb. per square foot hour.
Pressure = 120 lb. absolute.

$$D = \frac{25 \times 18}{120 \times 1.206} = 3.1$$

Pressure, 150 lb. absolute.
Grate area, 50 sq. ft.
Coal consumption, 25 lb. per square foot hour.

$$\frac{50 \times 25}{150 \times 1.206} = D = 6.9 \text{ in.}$$

A valve as large as this would be replaced by two of equivalent capacity.

The circumference = 3.14 × 6.9

Two smaller valves of diameter $\frac{6.9}{2} = 3.45$ will give the same circumference and the same discharge with the same lift.

George H. Musgrave[1] I have been asked to give my experience in the development and use of safety valves, which dates back over a period of about 30 years.

2 Commencing in locomotive service, we used the weight and lever type; but in lieu of the weight, we employed a spring balance at the end of the lever. This served its purpose very well, but left it optional with the engineer to carry pressure in excess of that allowed. To keep tab on excess pressure a tell-tale steam gage was used with an index hand which moved to the highest pressure reached by the steam-gage pointer and remained at this point. When the engine returned we could tell by that means whether the engineer carried more pressure than allowed.

3 The first pop valve that I had experience with was the Richardson open-type, exposed-spring, with two vertical studs and a crossbar on top, and the spindle extending two-thirds of the way through the body of the valve below the seat. The diameter at the bore was 2¼ in.; the first known so-called high-lift pop safety valve.

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[1] General Sales Agent, Star Brass Manufacturing Co., Boston, Mass.

4 In the discussion at the February meeting on the desirability of so-called high-lift and low-lift safety valves, Mr. Darling described methods of testing valves and showed designs of valves with which results were obtained, which had been known for years to the older manufacturers of safety valves. I refer to this merely to explain the difficulty we experienced with the Richardson type 2¼-in. bore. The lift of this valve was sufficient at times to raise the water from its normal condition, disturb materially its level in the boiler and, on numerous occasions when the engine was working steam, to take it over in the dry pipe and down to the cylinders.

5 The Richardson valve could not be regulated easily to reduce the steam pressure a given amount. Much depended on the accuracy of the springs, consequently the amount of blow-down would vary anywhere from 5-lb. to 15-lb. gage pressure. The adjusting ring was then applied, enabling us to overcome some of these difficulties by increasing or decreasing the area of the safety valve pop chamber.

6 On account of the excessive discharge of this type of valve and the noise of the steam blowing into the atmosphere, because of the high lift, some of the Eastern states passed laws prohibiting the excessive blowing, on the ground that it was detrimental to the community at large. Many accidents occurred because of the noise of the escaping steam; consequently the muffled valve came into general use.

7 This type of safety valve was larger in diameter than the Richardson, and varied from the original size of 2¼-in. bore up to and including 4½-in. bore. Being larger in diameter, with steam muffled so that it made less noise, it proved very satisfactory.

8 Mr. Darling refers to the most severe test on locomotive safety valves as being when an engine ascends a grade with the boiler full of water and working hard. A competent engineer fills his boiler before reaching the hill and climbs the grade with the least amount of water in the boiler necessary for safety, thereby keeping up the steam pressure. When he reaches the apex of the grade and starts down the other side, he will then apply his injector and the fireman will attend to the dampers and check the drafts.

9 The most severe test on locomotive safety valves, I think, is when an engineer is running at full speed, with a good fire, steaming rapidly, and is suddenly confronted with a danger signal, which causes him to stop, perhaps within the length of his train. The draft from the exhaust is shut off, but the steaming capacity of the boiler is not shut off proportionately at that time and the valves

almost immediately start blowing. Then the fireman should attend to his dampers and in other ways prevent excessive blowing.

10 There are several methods by which safety valves can be operated without excessive blowing, on stationary and marine as well as on locomotive boilers; although there is more blowing of steam on the latter than on any other type. In marine service the blowing of safety valves is the exception, and not the rule. They carry this still further in the Navy, and I am informed by competent naval engineers that the engineer on watch on a naval vessel is reprimanded if the safety valves blow.

11 The function of the safety valve is two-fold: (*a*) it gives notice of the highest pressure permissible; (*b*) it gives the alarm that more water or less fuel is needed. The experienced engineer and fireman, by working in harmony, can decrease the blowing of safety valves to a very appreciable extent. I have been told by engineers in the marine service, that through the use of safety valves with excessive lift and quick discharge, their engines have been plugged by taking over water. I have known of numerous occasions in locomotive service where there have been very disastrous results. If the same principle is to be introduced in high-lift locomotive safety valves that is now used in injectors to raise water, what is to prevent the syphoning of the water to the throttle valve, and its flowing through the dry pipe and into the cylinders? From my long experience, originally in locomotive service, afterwards in marine and stationary service and at the present time, on safety valves for all uses, I would suggest that the medium-discharge valve, that will not materially disturb the water-levels in the boilers, is the safest and most satisfactory valve to use. Any valve that will materially disturb the water-level and have a tendency to raise it, is dangerous.

12 It has been argued by some of the discussors that it was necessary to know the capacity of different size safety valves. This is a matter for the engineering fraternity, not for the manufacturer to decide. Most manufacturers can comply with the requirements of the engineer as to the efficiency of safety valves, and the amount of steam they will discharge at a given pressure per minute. This can be easily determined, but the engineer should state under what conditions this capacity is required,—whether natural, forced draft, or overload.

13 Mr. Darling's paper describes the tests made by a certain manufacturer, of a number of different types of safety valves made

by other manufacturers. It seems to me that if the Society is desirous of determining the best formulæ from which safety valve sizes can be figured, as well as the best rule for proportioning safety valve sizes to boilers of different kinds, and especially to those of the watertube and Scotch type under varying conditions, it would be best to have the tests made by a competent Board, the members of which should not be interested directly or indirectly in the manufacture of any one type of safety valve.

A. B. Carhart. The proper rating of safety valves and their relation to boiler capacity require simply the determination of the capacity of the valve to discharge steam, and that of the boiler to generate steam, and the fixing of a suitable relationship between the two. Napier's formula for flow of steam has been repeatedly verified by careful tests until it seems worthy of acceptance for valve calculations.

2 For valves of different designs, different percentages of the calculated discharge may be assumed according to the restriction of steam flow by discharge passages. In Steam Boilers, by Peabody and Miller, we find the statement that a 2-in. pop safety valve tested at the Massachusetts Institute of Technology was found to lift from 0.07 in. to 0.08 in. The valve had a conical seat with an angle of 45 deg. The actual flow was about 95 per cent of the calculated flow. The large discharge efficiency of this valve is probably due to the peculiar form of its lips which utilize to the greatest degree the impact force of the steam flow; and to the fact that the regulating ring is entirely below the edge of the lip, with additional vents which add to rather than decrease the outlet opening when the valve begins to blow.

3 The effective opening in a bevel-seated valve is approximately $\frac{7}{10}$ of the vertical lift of the disc. In some valves, however, the design is such as to reduce this area of flow beyond the valve seat, and allowance for this limitation of discharge area, less than the valve-seat opening, should be made. In the patent issued to Richardson, the inventor of a still common form of bevel-seated pop valve, January 19, 1869, the following reference is made to this point:

> The said means, so patented, consisting in forming the valve with a surface outside of the ground joint for the escaping steam to act against; the said surface being surrounded by a projecting or overlapping lip, rim or flange, leaving a narrow space for the escape of the steam when the valve is opened, but which, al-

though of greater diameter than the valve seat, by reason of the said lap, presents a less area of opening for the escape of steam than is produced at the valve seat.

4 The amount of the overlap of the lip of the regulating ring is often as much as 0.02 in. or 0.03 in., which the disc must lift before there is a free outlet, and the passage to the open air may easily be 15 per cent or 20 per cent less than the apparent calculated lift would indicate, even after allowing for $\frac{7}{10}$ of the vertical measurement.

5 The satisfactory behavior of the valve depends upon the intelligent adjustment of its regulating device to suit peculiar boiler conditions. Attention was called to this in the report of the Special Committee of Supervising Inspectors, in 1875, p. 30. Valves were submitted for testing, which had previously been adjusted, in most cases to boilers which furnished but a small volume of steam, but when the competitive tests were made the valves were found to need readjusting, since the volume of steam furnished was equal to or beyond the capacity of the valves.

6 This same committee also made a series of tests on several sizes of common ball and lever safety valves of the old type, on page 21 of the pamphlet, to the effect that:

> The maximum areas obtained were a little in excess of the above (average), but it must be kept in mind that the boiler evaporated at the rate of 2500+ lb. of water per hour some portion of the time;
>
> Also, that the diameter of a safety valve is not an infallible test of its efficiency;
>
> That the lift which can be obtained on a safety valve, other conditions being equal, is a test of its efficiency;
>
> That the lift of a safety valve depends upon the velocity and weight of the escaping steam;
>
> That the valves with small areas made a greater excess than those with large areas, even when the former recorded a greater maximum of effective area;
>
> That the common lever safety valve, when constructed upon correct principles, employing good material and workmanship, will correctly indicate the maximum pressure of steam in a boiler, and, when suitably proportioned, relieve the same of all excess.

7 The excess referred to means "the number of pounds which the valves allowed the pressure to exceed that at which they opened." If these comments by the committee have any proper bearing upon the present question of pop valves at all, the meaning is plain that small valves of high lift have less discharge capacity for equal areas of effective opening than valves of larger diameter with moderate lift; and that valves of very small lift give proper relief if suitably proportioned to the boiler capacity.

8 One danger to be guarded against is the failure of the valve to open at the critical moment. The greatest cause of sticking is the binding friction of the disc guides against the side of the throat. With large lift the deformation of the spring is great, with resultant side thrust on the guide wings, which have been known to wear $\frac{1}{8}$ in. in diameter in a few months' service. Under such conditions the valve disc will not seat properly and cannot as certainly be relied upon to open and close promptly or keep tight. Hence a small valve with large lift is not the equivalent of a large valve with larger diameter, requiring less lift to give the same discharge.

9 For locomotive valves, where the steaming capacity of the boiler is large, the steam is freely discharged, and the valves are subjected to inspection, the vertical lift may properly be as much as 0.07 in. or 0.08 in., but it should not be more at such high working pressures, with frequent blowing. For stationary valves it should not exceed 0.1 in. and may well be as much less as the conditions will permit. Considerations of stability and safety suggest to conservative engineers that the amount of lift be reduced rather than increased.

10 The lift of any valve can be varied considerably at will. Without any alteration of design or parts it may be made 0.04 in. as the minimum or 0.1 in. as the maximum by a single turn of the regulating ring; and to meet extreme demands these limits can be extended by a simple substitution of another spring, without changing any of the working parts of the valve. That valve which affords relief with the least lift of the disc, or with least spring distortion, and with the least strain upon the boiler, is the safest and most efficient in design.

11 For stationary boilers, generally used at the lower pressures, 5 in. diameter of valve seat should be the limit, and this is the largest valve permitted by law in Massachusetts. The rules of the steamboat inspection service provide that no valve shall be larger than 6 in. in diameter, and they seem to have seriously considered reducing this limit to $4\frac{1}{2}$ in. That supervising engineers seldom specify valves larger than 5 in. diameter is a fair indication that such practice is within good judgment, and some manufacturers do not list larger sizes as regular. In some jurisdictions, where the rules have been recently revised, a 4-in. limit has been fixed.

12 Pop safety valves for locomotives should not be larger than $3\frac{1}{2}$ in. diameter at the seat, as at 200 lb. pressure the total load upon the valve disc in the bevel-seated valve is then 1925 lb.,

increased perhaps 500 lb. to maintain the lift when the valve opens, a total of 2400 lb. This means an enormous force to be controlled even at moderate lifts. In the flat-seated annular valve this initial load is only 1575 lb., increased to about 1800 lb. when the valve lifts, since the possible maximum is under all conditions less than the initial or minimum load upon the bevel-seated valve; although the effective discharge area in the 3½-in. size, with the proper 15 per cent allowance for the central auxiliary outlet, amounts to little more than 1 sq. in. at only 0.08 in. lift of the disc, or something over 3 lb. of steam per second, according to Napier's formula. This area of discharge opening is equivalent to a vertical lift of 0.128 in. in a 3½-in. bevel-seated valve of 100 per cent theoretical discharge efficiency.

13 The capacity would be proportionately increased in a 4-in. valve, but as all the parts would become unwieldy in weight and size, there seems to be no good reason for opening up such a large hole in the boiler, with a seat circumference of 12½ in., requiring a valve weighing something over 75 lb. Certainly the 4-in. size is the extreme that can be recommended, even taking into account any difference in cost. In the bevel-seated type a 4-in. locomotive valve of theoretical efficiency should lift 0.113 in. to show 1 sq. in. discharge opening, and might better be divided into smaller units, considering that the initial spring load in such a valve is over 2500 lb. and when the valve opens may exceed 3000 lb. to react through this distance.

14 Experience indicates an effective area of 1 sq. in. as the largest unit of valve capacity advisable for large boilers of the steaming capacity of modern locomotives. The strain upon the boiler is dangerous when a large valve is suddenly opened at high pressure and as suddenly closed. Water may be drawn out of the boiler with the steam, the surging and priming endanger the cylinders and choke the safety valve, and boiler-scale deposits cut the seats and cover exposed threads. Much better practice is that more commonly followed, using three valves of comparatively small size, set to open 2 lb. or 4 lb. apart, and called into operation in succession as the steaming conditions require. This prevents serious rise in boiler pressure before relief.

15 From careful observation, we know that in actual service two 3½-in. or three 3-in. flat-seated valves, even when regulated to permit a comparatively limited vertical lift, have proved ample for the largest locomotive boilers under the most severe requirements

of heavy steaming and freight service on mountain railroads, and under such circumstances the third of a series of three 3-in. valves has never been known to blow; while records show that on many locomotives the pressure has never increased sufficiently to reach the second valve, set at 2 lb. or 4 lb. above the first. The effective discharge area of a 3-in. annular flat-seated valve, with a maximum lift of 0.08 in., is a little more than 0.85 sq. in., and is capable of discharging 2½ lb. of steam per second at 200 lb. pressure, so that the greatest combined capacity of the three 3-in. valves would be about 7½ lb. of steam per second.

16 Mr. Whyte is thus correct in saying that safety valves need not have a discharge capacity equal to the steam-generating capacity of the locomotive boiler under forced draft. Experience has demonstrated a total valve capacity theoretically equal to 2 sq. in. discharge area as safe and efficient for ordinary locomotives with 35 sq. ft. of grate area, and 3 sq. in. for the largest ones, having as much as 50 sq. ft. of grate area, and not more than two-thirds of even this provision has ever been called into service. To provide greater capacity than is required means either multiplication of valves or increased capacity in each unit, regardless of certainty of operation and freedom from repairs.

17 A satisfactory solution of this whole question seems to be to equip a locomotive with three valves, each of 3-in. or 3½-in. diameter, in proportion to the capacity of the boiler, as follows:

a A muffled valve seat at 200 lb., permitting only 3 lb. or 5 lb. drop in steam pressure when it opens, to act as a working value for all ordinary running conditions, leaving the locomotive with proper pressure to continue its work after the blowing of the valve.

b A reserve valve of the same type, set at 202 lb. or 204 lb., to take care of unusual conditions under which the steam pressure might possibly continue to rise in spite of the first valve, and regulated to permit a drop of 5 lb. or 6 lb., not letting the pressure go much below the normal 200 lb.

c An emergency valve, of the same type but different proportions of disc, and with an extremely resilient spring, to open at 206 lb., with an adjustment set to insure an exaggerated lift and large discharge that will cause the boiler pressure to drop 15 lb. or 20 lb., practically putting the locomotive out of service until this drop in pressure can be regained. The blowing of such a valve, on rare occasions, would indicate an extreme condition calling for immediate attention from engineer, fireman, and conductor.

18 To distinguish these valves in service, some difference in design or marking might be established, or the working valves might be muffled and the emergency valve be of the open type.

19 The common practice has been to design and regulate locomotive valves to cause the steam pressure to drop 3 lb. or 5 lb. below the opening point before closing, and the regulating ring or device would be set at the time of testing to accomplish this with a period of blowing that would cause the least shock to the boiler with efficient relief. The greatest difficulty that valve makers meet today is not the simple problem in mechanical design of building safety valves with large discharges or lifts, but in educating and persuading operating engineers actually to utilize the valves to their intended normal capacity, instead of resetting the regulating adjustment so as to throttle the valve action beyond reasonable limits, to prevent what they regard as waste of steam when the valve does open in the performance of its proper function. It is not reasonable to expect a valve, designed and regulated to lose 5 lb. in boiler pressure, to perform equally well when the regulating device is adjusted so that the pressure is allowed to drop only 1 lb. or 2 lb., as is actually the condition on many railroads today. Engineers should not complain of a lack of valve capacity so much as of their own blindness in throttling the valves they already have.

20 In small valves, too great lift of the disc gives a discharge area through the seat too large in proportion to the disc area or the diameter of the boiler connection. This is the chief cause of the chattering, exhibited in some valves, involving the destructive hammering of the seat and an inefficient, spasmodic steam discharge. Mounting large valves upon long pipes of small diameter or with bends or elbows, instead of connecting them directly upon the boiler, will develop similar unsatisfactory conditions, if the flow of discharging steam is not sufficiently re-inforced in proper volume from below. It is not enough merely to blow out the steam in the throat of the valve; conditions down inside the boiler must be relieved without undue strain.

Sidney B. Paine said, the question is a great deal broader than that of lift. We do not know today whether a 4-in. safety valve is capable of relieving a 100-h.p. boiler or a 400-h.p. boiler: the rules of the Steamboat Inspection Service, the Massachusetts and the Philadelphia rules, are all based on diameter without taking into account the lift of the valve-seat, and hence are erroneous. No man could go into court and swear that he knows that the commercial safety valve he has bought will take away all the steam which the boiler would generate with the other outlets closed. This matter of a standard of measure by which valves may be rated is one of the most important that has come before the Society for a long time.

M. W. Sewall. It has been suggested that investigations be made by the government and by boiler insurance companies in order to insure public safety by formulating exact regulations for the proportions of valves, the lift, etc. These suggestions are in the line of tying all manufacturers down to exact rules which would standardize the output along rigid lines, a condition that seems very undesirable. Manufacturers should be allowed the largest liberty in design. The public authorities and insurance companies should, it seems to the writer, establish means of regulation in regard to the following:

a Flange diameters for various rates of discharge.
b Requirements as to minimum discharge of pounds of steam per second within given ranges of pressure.
c Requirements as to non-corrosive seats or other operating parts, strength of parts, means of operation by hand, and security against being put out of adjustment by ill-disposed persons.

2 Whatever importance other matters may have to manufacturers and designers they are not of interest to the public. It would perhaps be desirable to have formulated by them the details of a form of valve that would be acceptable to the insurance companies and other authorities, so that all manufacturers would know of an acceptable form.

3 All details of design, however, and especially such items as form of seats, springs, lift of valves, etc., should be subject to the most liberal treatment. If variety of design is allowed there will be that incentive to develop different forms and types that is requisite to the development of the best methods and designs.

Albert C. Ashton. I am in accord with those who think the Society could profitably investigate the practice among steam-users and formulate for general use a rule giving the proper size of pop safety valves for boilers, taking as a basis the average efficiency obtained from the present standard makes.

2 After a practical experience of over twenty years, I am opposed to high-lift valves, since they open and close so suddenly as to injure the boiler and its connected fittings, as well as the valve itself. Such valves were tried out many years ago and have been discarded.

3 I am satisfied that any revised rule for the size of pop safety valves should not prescribe a capacity of relief that could be obtained only with a high-lift valve, as suggested in the contributions by Mr. Darling and Mr. Lufkin, wherein they approve of a lift equal to $\frac{1}{32}$ of the diameter of the valve. This is excessive, and so far as I have heard has been approved by only one valve manufacturer.

4 In my opinion, it would not be taking a step in advance to require higher-lift valves than those now in common practice. In evidence of this, from my own observation, pop safety-valve manufacturers have experienced more trouble from their standard valves giving too great rather than too small a relief. It is an exception to criticise a reliable make of valve in good working order on account of deficient relief, and even then the fault can generally be attributed to the application of too small a valve.

5 It would be desirable for engineers to specify the required relief, but I think it is not necessary or advisable to specify the lift, for on many applications high-lift valves are not at all suitable.

Mr. A. F. Nagle. I have computed the table herewith upon the size of safety valves for boilers of a given power, based upon the following data:

a A boiler horse-power is the term used to express the evaporation of 34.50 lb. of water per hr. from and at 212 deg. Fahr.

b A spring safety valve can and should be depended upon to lift $\frac{1}{32}$ of its diameter.

c The flow of steam follows closely Napier's formula, reduced to 92½ per cent by Mr. Darling's experiments (par. 24).

d The formula used in the computation is

$$\text{h. p.} = 0.0951\, D^2 P$$

where

h. p. = boiler horse-power.
D = diameter of valve in inches.
P = absolute steam pressure.

2 In using this table, allowance must be made for what is likely to be the maximum horse-power of the boiler and not its normal rating. Fifty per cent overload is not unusual, and double the rating, while not impossible, is not liable to pass through the safety valve.

HORSEPOWER OF BOILERS AND SIZE OF SAFETY VALVES

Steam Pressure Pounds	Safety Valves					
	2 in.	2½ in.	3 in.	3½ in.	4 in.	4½ in.
100	44	68	98	134	175	221
125	53	83	120	163	213	269
150	63	98	141	192	251	318
175	72	113	162	221	289	366
200	82	128	184	250	327	414
225	91	142	205	280	365	462
250	100	157	227	309	403	510

NOTE.—Roughly every 4 lb. of coal burned per hour represents one boiler h. p.

JEROME J. AULL. The opening paper on the subject of safety valves was intended, apparently, for the purpose of giving a certain manufacturer of high-lift valves a chance to exploit his product. This conclusion is evident from a number of rather mysterious references such as "The elaborate tests which have already been made—data from which it is hoped may be presented in the discussion of this paper"—and "This is considered an appropriate time and place to make available such information as those who have it may wish to present."

2 It is to be regretted that the evidence of selfish commercialism is so apparent, since it lessens the importance of the deductions resulting from the "experiments" which were made. They do not bear the stamp of approval of disinterested investigators, hence, from a universal point of view, are of little value.

3 In my opinion the proposed rule should include a term for a fixed lift rather than a variable one, for the reason that with the latter would result a hopeless confusion of safety-valve openings in

boilers of the same size. Thus under Mr. Darling's rule a boiler of a certain size might be provided with a safety-valve connection varying from 2½ in. to 4 in. in diameter, depending upon the make of valve specified. It would be far more convenient and satisfactory to standardize safety-valve connections so that any valve having the required capacity could be used. To do this it would be necessary that the valves themselves be standardized within certain set limits, and this could be done only by a body of disinterested engineers, properly authorized to investigate the subject.

4 The proper lift is a more or less debatable question, but it is reasonable to suppose that the average practice of the leading manufacturers, disregarding the minimum and maximum, is very nearly correct. High-lift valves are no improvement nor are they necessary for general purposes. If they were, the standard designs could be very easily altered by manufacturers.

5 If the lift is too high the seats and spring-bearings are subject to a severe pounding action; there is more danger of chattering; close adjustment is not possible; there is danger of lifting of water; and the boiler seams are sometimes strained to the opening point.

6 Having determined the proper lift, it becomes a very simple matter to formulate the rule governing safety-valve discharge areas or seat-opening diameters. The only thing remaining would then be to determine what variation there should be in valve sizes to suit various pressures.

A. J. Hewlings. It is a question whether the amended formula of the United States Steamboat Inspection Service has any advantage over the former rule based on square inches of valve area to square feet of grate surface, because of the alleged extreme variations in the capacities of the different types of valves of equivalent list or catalogue sizes, all of which will be passed by the inspectors.

2 To overcome this condition on the basis of a proposed amended formula, each manufacturer would be required to furnish a detailed schedule of capacities of each size and style of valve under different pressures of steam. In furnishing such a schedule, all tests must be made under exactly similar conditions, with the same boiler, of ample capacity so that fixed time-periods of blowing-off can be accomplished while the boiler maintains a continuously even pressure. In no case should the boiler pressure go low enough to permit the valve to close itself.

3 A question arises as to the reason for the creation of high and low lift valves and whether it is not in most instances by accident rather than design. The assumption is that manufacturers, in designing their own particular style of valve and embodying therein the essential features of mechanism, have produced varying designs and dimensions of projecting discs and regulating rings, which, together with varying types of springs, are principally accountable for the distinction between high and low lift valves and the great differences in capacity of corresponding catalogue sizes. For these obvious reasons it does not seem possible to formulate any definite rule that could be put into general practice while there are so many variations in design.

4 A reasonably consistent solution of this problem might be reached, however, by the adoption of a general ruling requiring that all makes of valves, regardless of design, shall be so proportioned that the steam or self-lifting features shall conform to uniform discharging capacities for catalogue sizes. In this event, it would probably be sufficient that listed capacities of each catalogue size be based on a single given pressure of steam, assuming that different pressures would proportionately give uniform capacities, varying of course as the pressure varies, but in direct ratio with the different pressures of steam. This method would practically accomplish the desired results and conform to the present amended formula of the Steamboat Inspection Service.

AUTHORS' CLOSURES

F. M. Whyte. It appears to me that the discussion of this subject has been very profitable, both to those who have considered it seriously, with the desire to profit by it, and to those few who have treated it with asperity.

2 It has been made apparent that there is much to be learned on the subject, and it is plain that some are endeavoring to add to the present knowledge concerning safety valves; those few who have attempted to discredit the efforts being made to increase our knowledge on the subject, and the spreading of such new data, will, no doubt, profit most by the discussion, providing their future efforts are better advised than was their discussion of the subject.

3 The object of presenting the subject was to have put on record as much information about safety valves as might be possible, to

urge the necessity of future investigations, and if possible to give them direction. It is very evident that the object will be fulfilled.

Philip G. Darling. Many different values for safety-valve lifts are at present being advocated, together with arguments why each is the highest safe or advisable value for general use. Recent articles place this maximum limit variously at 0.05 in., 0.06 in., 0.08 in., 0.09 in., and 0.14 in., for the same size valves. The diversity of these values raises the question as to what is the basis in setting such limits, and whether there are any inherent elements or principles of design calling for this restriction.

2 It is well known by those in touch with foreign manufacturers that valve lifts, spring compressions and other valve elements are being successfully, and in places universally used, which are radically different from what has been the general practice in this country.

3 Two cases will illustrate this. The springs on 3¾-in. triplex valves of the Thornycroft design, used widely in English marine practice, are not only of the exposed type, but have, when set for a designed pressure of 250 lb., a compression of 4 in. These are regular safety valves of the same principles as our own duplex valves. To those who would condemn a compression of ½ in. to ⅝ in. as radically high and unsafe this instance should be suggestive and help to broaden their conceptions of the possibilities of safety-valve design. Again, in *London Engineering*, February 26, 1909, reprinted in *Power*, March 30, 1909, J. H. Gibson tells of exceptionally good results obtained in a valve having 0.21-in. lift. He says: "We think we are justified in the assumption . . . . that anything tending to reduce the size of these important fittings (safety valves), which have been growing to abnormal proportions of late, is a step in the right direction."

4 These two illustrations indicate very clearly that in England no inherent valve conditions have been discovered limiting spring compressions to ¼ in. or valve lifts to 0.05 in. and 0.08 in. Nor in fact are such arbitrary limits actually restricting the progress of design in this country.

5 High lift is not synonymous with excess safety-valve capacity. A boiler's evaporation absolutely determines the necessary safety-valve capacity. In a given boiler the pounds of steam per hour which the valve should be able to relieve can be definitely figured and all that is further needed, in making the correct valve specification, is the capacity of the safety valves.

6 It is not a question of lift for itself, but of requisite relieving capacity, and if this is obtained with a 3-in. instead of a 4-in. or $4\frac{1}{2}$-in. valve there is a positive, real advantage, not only in original cost but in the maintenance and better action of comparatively small rather than large valves.

7 High or low lift is a question of personal preference on the part of the buyer, a question of legitimate argument for and against on the part of the seller. It is probably better for the progress of safety-valve design that manufacturers should *not* agree, that buyers should have a preference to draw from, that valves having different lifts should be out in general competitive trial as they are today.

8 It is thus not a uniformity in the lifts of different valves which the engineering public should demand, but rather the practice of stating relieving capacities, based on the actual lifts existing in the valves themselves. The assumption of an average lift in rating capacities of different makes of valves is a method not only liable to such large error as to be entirely inadequate and unsafe, but it must act as a great restriction to progress in valve design. The logical policy is for valve-makers to continue to advocate each his own lifts and capacities for valves, but on the other hand for all to agree and to state, and if desired, to guarantee, what the actual relieving capacities of their valves are. If the capacities were stamped upon the valves, as already done by one maker, it would give a rational basis for use in the application of safety valves to boilers.

9 It has been objected that capacities thus published could not be verified without actual capacity runs, such as the Barberton tests recorded in my paper, on the ground that in some valves the effective area of discharge at the seat, upon which the formula is based, is not the smallest discharge area; or even if it is, that there is is a material throttling or holding back of the steam flow. Valves containing the original Richardson adjusting ring have been cited as designs in which this choking occurs.

10 In order to secure information upon this matter prior to conducting the direct-capacity tests at Barberton referred to in my paper, the effective discharge areas at the seat and at the most contracted passage between the lip and adjusting ring were figured and plotted for the different valves tested at different lifts. Further, a $3\frac{1}{2}$-in. valve was constructed having this Richardson ring and projecting disc lip design, and for the same valve another disc and ring in which the projecting lip was cut entirely away. In the former the discharging steam was deflected through practically 90

deg., and in the latter the steam had a free straightaway passage. These two designs were radically different and fairly represented the extremes of what on the one hand seemed to be a choked or impeded steam discharge passage and on the other a free open one.

11 The effective discharge areas of the two taken at the seat and at the most contracted part of the passage between the lip and rings are given in the table in square inches for different lifts.

TABLE 1 EFFECTIVE DISCHARGE AREAS

Valve with projecting lip and Richardson ring			Valve without the lip	
Lift	At seat	Most contracted point beyond seat	At seat	Most contracted point beyond seat
0.02	0.16	1.20	0.16	2.01
0.06	0.47	1.40	0.47	2.14
0.10	0.79	1.76	0.79	2.29
0.14	1.11	2.27	1.11	2.43

These areas, taken with Napier's formula, give a method of figuring the theoretical pressure existing in the "throttling chamber" under the disc-lip; that pressure being to the boiler pressure as the effective discharge area at the seat is to the most contracted area between the lip and ring beyond. The highest pressure thus indicated in the throttling chamber is less than 50 per cent of the corresponding boiler pressure. This pressure in the "throttling chamber" being the discharge pressure of steam passing over the valve seat, and the full flow of Napier's formula being practically unaffected by any discharge pressure less than 60 per cent of the original or boiler pressure, the theoretical conclusion is that the discharge from neither of these valves would be affected by the disc design or discharge areas outside of the valve seat.

12 This preliminary reasoning was corroborated in the direct-capacity tests run at the Stirling Works of the Babcock & Wilcox Company at Barberton, Par. 23, *b*, of my paper. This area between the lip and ring of the regular Richardson ring design was even further contracted by running the adjusting ring up a full additional turn ($\frac{1}{16}$ in.) under the projecting lip as referred to in Par. 23, *c*, and even this did not materially alter the discharge.

13 The conclusion is, that the variations in design of different makes of safety valves, though considerable in appearance, are in

no case of a character to alter the direct relation of lift to capacity, and thus that safety-valve relieving capacities do vary directly with the lift obtained with valves, that there are no exceptions to this as valves are being constructed, and, therefore, that the basis upon which the proposed safety-valve capacity formula has been founded is sound.

14 The discussion has contained references to disastrous results to boilers, such as the opening up of seams and fittings due to the sudden release or cutting off of steam by the safety valve. If such disaster could result from the action of even the largest valves it would be a legitimate argument only against excess valve-capacity and never against a proper application of either high or low lift valves. As bearing on this it should be noted that enginemen generally close the throttle with a single straight push of the lever, giving nearly, if not quite, as sudden a closing as a safety valve. On the larger passenger engines this means the sudden stopping of the steam-flow from the boiler at the rate of 20,000 lb. to 30,000 lb. per hour, which is three or four times as great a steam-flow as through the corresponding "high-lift" safety valve which this locomotive would have. A 3½-in. valve of this type would discharge at the rate of from 8000 lb. to 11,000 lb. an hour, the former at closing, the latter at opening.

15 Locomotives having 3½-in. safety valves will generally have about 2-in. blow-off valves, giving a vent opening of 3.14 sq. in. These valves are placed below the water-level and are generally operated with a straight lever handle or pneumatically, giving an abrupt open and close from full area. Suddenly shutting off a flow of water, which is a comparatively incompressible substance, would seem to be more of a shock than shutting off a similar flow of steam, which is an elastic, compressible substance forming a perfect cushion. Hence, the shock to the boiler caused by the closing of the safety valve handling steam instead of water, and with but ⅓ to ¼ the area of the blow-off valve, must by conrast be inappreciable. Yet this blow-off arrangement is considered good practice.

16 The larger the safety valve compared with the boiler the greater the shock to the boiler due to its action, if such shock exists. A 5-in. valve mounted directly upon a 94-h.p. test boiler would increase or accentuate this tendency to strain over say a 3½-in. valve on an 800-b.h.p. locomotive surely 12 or 13 times. Yet with a most sensitive boiler pressure test-gage graduated to pounds and mounted upon this 94-h. p. test boiler, absolutely no recoil of

the gage hand upward either at the opening or closing of a 5-in. valve is perceptible. It would seem that some increase of pressure such as would be indicated upon the gage would be positively necessary to transmit a strain to the boiler.

17 Two cases have recently come to my notice in which locomotive safety valves have loosened from their spud connections and have blown off while the boiler was under its full steam pressure. One was a 3½-in. and the other a 4-in. valve, which therefore opened areas of 9.6 and 12.6 sq. in., respectively, while the maximum corresponding safety-valve discharge area could be but a little over one square inch. Yet no damage to the boilers was experienced. The blowing-off of 2-in. locomotive whistle connections has been cited as a not infrequent occurrence. The steam-relief in such accidents is of course more sudden than with a safety valve, and the fact that this opening of ten to twelve times the maximum discharge area of the corresponding safety valves results in no further inconvenience than the replacing of the fittings raises some question as to the actual disaster impending in the use of valves having a discharge area of but 1 sq. in.

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BOARD OF COMMISSIONERS OF ELECTRICAL SUBWAYS IN THE CITY OF NEW YORK, Vol. 1–2. Gift of H. S. Wynkoop.

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Notes on Determination of Experimental Equations. (Reprint from The Wisconsin Engineer, December 1908.) By L. F. Harza. Gift.

Ordinance Governing the Department for the Inspection of Steam Boilers and Steam Plants, City of Chicago, May 1903. Gift.

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RECENT RESEARCHES AND FUTURE WORK. By R. T. Glazebrook. (National Physical Laboratory.) Gift of C. W. Rice.

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EXCHANGES

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CATALOGUES

AMERICAN BLOWER CO., *Detroit, Mich.*

"Sirocco" Blowers. Cuts and description, detail construction of "Sirocco" fans, and their application in trade.

COLLINS WIRELESS TELEPHONE CO., *Newark, N. J.*

COLLINS WIRELESS BULLETIN, *February, 1909.*

Containing: Wireless dirigible airships; Artom directive wireless telegraph system; Wireless electric lights.

DUNCAN ELECTRIC MFG. CO. (Bulletin No. 8.) *January 1909.*

Direct-Current Integrating Wattmeter. House Type; Model E. Cuts and description of detail construction.

Foster Engineering Co., *Newark, N. J.*

Valve installation in the boilers of the Singer Building. Foster Pressure Regulator, cut showing construction.

General Electric Company, *Schenectady, N. Y.* Train Lighting with G. E. Tantalum Lamps. (No. 3757.) Tricoat Wires and Cables. N. E. Code Thickness of Insulation. (No. 5196.)

Goldschmidt Thermit Co., *90 West St., New York, N. Y.*

Instructions for use of Thermit in Railroad shops.

Harriman Bros., *Boston, Mass.* Description of a Rotary Engine, by J. E. Harriman. (Lecture delivered at the Tech. Union before the Mech. Soc. of Mass. Inst. of Technology.)

A General Report on the Harriman Rotary Engine, by F. C. Morton.

A Report of Economy Tests on the Harriman Rotary Engine, by E. F. Miller.

Kerr Turbine Company, *Wellsville, N. Y.* Kerr Steam Turbine. (Bulletin no. 8, May 1909.)

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Manning, Maxwell & Moore, *85–89 Liberty St., New York, N. Y. 1909.*

Catalogue of milling, boring, threading machines, planers, lathes, drills, saws, cranes, grinders, presses, shears, and machine tools.

McNab & Harlin Mfg. Co., *50–56 John St., New York, N. Y. 1909.* (10th edition.)

Catalogue of iron and brass fittings of every type for steam fitters' use.

Moore & White Co., *Philadelphia, Pa.*

1903. Price list of coupling, friction clutches, pulleys, shifters, and shafts.

1906. Catalogue of speed changes, cone-pulley transformers, tables of dimensions, one detail drawing and dimensions of the Moore-White Friction Clutch.

Niles-Bement-Pond Company, *New York, N. Y.* Heavy Milling Machines.

Northwestern Expanded Metal Co., *Chicago, Ill.*

Formulas, diagrams, and data of strength, stresses, and uses of beams and columns in building materials.

United Engineering & Foundry Co., *Pittsburg, Pa., 1908.*

Catalogue of Rolling Mill Machinery, including Shears, Lathes, Accumulators, Cranes, Cars, Gears, etc.

Westinghouse Electric & Mfg. Co., *Pittsburg, Pa.*

Protective Apparatus for lightning, as lightning arresters, safety spark gaps. Luminous radiators and air heaters.

Willcox Engineering Co., *Saginaw, Mich.*

Uses, Construction and Operation of Willcox Water Weigher, Bulletins 3, 4 5, 6.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

067 Manager for factory located at Newark-on-Trent, England.

068 Instructor in mechanical and architectural drawing, for Tuesday and Thursday evenings, October to May. Location, Queens Borough, City of New York. Experience in teaching and tact required. Familiarity with manufacturing, drafting room methods essential.

069 Selling engineer wanted for steam condensers. Location, Philadelphia.

070 Wanted, ambitious young man, with selling experience, to represent in Chicago a company manufacturing transmission machinery.

071 Wanted, young technical graduate with good scholastic record and at least two years' practical experience, for position of assistant in laboratory of Engineering School; salary $1000 for academic year. Location, Massachusetts.

072 Man experienced in general machinery; to work on board and handle six men under general instruction of Chief Engineer; experience absolutely essential on jig work and general design. Further, experience in transmission, conveying, gears, etc., preferred; good opportunity for live capable man; give full details of experience, salary expected, and positions previously held, naming employers in first letter; all information held strictly confidential; immediate opening; location, Ohio.

MEN AVAILABLE

254 Member, with fifteen years' experience, an expert on gas engines, gas producers, gas furnaces, gasoline and oil engines, pumping machinery of every description, air compressors, blowing engines, rolling mills, etc., both designer and superintendent, desires change. Now chief engineer of medium-size shop; would prefer larger concern or one willing to take up these branches anew. University graduate, best of references.

255 Manual training and university technical graduate; age 33, thirteen years' practical experience in machine shop, drafting, designing, testing, estimating, etc., has employed and had charge of men; desires position, preferably in Philadelphia, or vicinity. Would consider an opportunity in the commercial line of engineering or manufacturing.

256 Representative of gas power company, desirous of entering into correspondence with a few firms in the machine line in the United States interested in the development of trade in Europe, Asia, and Africa, with view to forming arrangements to represent them.

257 Chief draftsman and designer of special machinery for manufacturing firm. Five years' experience power plant construction, irrigation and general engineering. At present, gas and mechanical engineer for corporation. Executive ability. Position as superintendent of maintenance or construction or as mechanical engineer with contracting or consulting firm.

258 Associate, age 29, technical graduate, two years' experience general drafting, four years of teaching and research in the field of the gas producer, gas engine and steam boiler, capable of directing and handling both mechanical and chemical sides of this line of work, desires position as professor or assistant professor of experimental engineering or as testing engineer in charge of experimental work for a manufacturing plant.

259 Member, long experience in pumping machinery, air compressors, Corliss engines, condensing apparatus; desires position as chief engineer or chief draftsman near New York.

260 Assistant engineer, age 29, Cornell University, M. E., executive and designing ability and good business judgment, ability as investigator and organizer. Broad general experience in mechanical and civil engineering on railroad and car work, steam boilers, gas engines, industrial plant equipment, power house, hydroelectric work, special designs; seeks position as works manager or engineer in moderate-sized progressive concern.

261 Affiliate, and associate member Am. Soc. C. E., eight years' experience on design and construction in steel and reinforced concrete, especially familiar with power-houses and structures for street railway and lighting companies; open for engagement, June first.

262 Junior member, graduate mechanical engineer, seeks position which will offer a future. Three and a half years' general experience as draftsman, steam engineering and special work. Present salary $125 per month.

263 Assisting manager at present engaged with company operating blast furnaces, mines, etc., technical education, familiar with manufacture of merchant pig iron, including Gayley Dry Blast, and all details entering into plant operation; can handle men and produce results.

264 Electrical and mechanical engineer, Cornell graduate, age 32, desires change of position. Practical experience includes power plant and shop superintendence; electric and pneumatic power distribution; applications of electricity

in manufacturing plants, particularly individual motor drive; specification work and correspondence. Broad knowledge of general machinery; executive and business ability; highest endorsements.

265 Member, with business training, going to Europe about the middle of June, would like to act as representative for responsible concern where honesty and integrity are required.

266 Member, 20 years' experience in managing shops, building heavy machinery, successful in bettering production, good designer, desires position as manager or chief engineer.

267 Mechanical engineer with broad experience in sugar machinery desires position as chief engineer or representative with manufacturing concern.

268 Member, with twenty years' experience as superintendent and manager of large manufacturing concerns, open for engagement. Applicant is up-to-date in all the latest shop methods and able to produce large quantities of work at minimum cost. Can handle the office and carry out the business end.

269 Engineer, age 30, technical graduate, desires position as manager, superintendent or engineer; experience in shop, drafting, devising, and installing cost, shop and production systems, and in electrical installations for industrial plants.

270 Affiliate (Gas Power Section), supervising draftsman or assistant superintendent, age 31, practical man with technical education; five years shop, three and one-half years drafting-room experience; gas engines, gas producers and automobiles; Middle West preferred.

271 Sales engineer now connected with prominent firm of engineers and contractors; fifteen years' experience with pumping machinery, air compressors, and steam-plant contracting. Considerable experience in directing sales campaigns and handling salesmen; capable executive and organizer: prefers location on Pacific Coast, Denver or Mexico.

272 Member desires position as superintendent or manager; now employed; principal experience in manufacturing machine shop and gray-iron foundry, as organizer and executive; medium and small work in quantity and quality, such as steam and power pumps.

273 Member, competent salesman and engineer, located in New York City. Experienced estimator and designer on special work and manufacturing plant equipments. Open for engagement to act as Eastern representative.

274 Junior, twenty-eight years of age. At present, designing engineer with large company building anthracite producers, gas engines, Corliss engines and special machinery. Have had excellent experience in shops and in erecting engines and machinery. Desire to take position as assistant to chief engineer or as chief draftsman. Prefer to locate in New York or vicinity. Can furnish the very best of references as to ability and character.

275 Mechanical and electrical engineer, fifteen years' experience in railway, lighting and industrial plants. Manager, designer, or superintendent of construction.

276 Junior technical graduate, at present located in drafting room of motor power department of railroad, desires to change; has served a three years' special apprenticeship in shop and round house and four years drafting, part of the time engaged in locomotive testing and also testing different railway appliances.

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HAWKS, Arthur S. (1904; 1909), Engr. Power Dept., Bethlehem Steel Co., South Bethlehem, and 313 Wall St., Bethlehem, Pa.

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HOUGH, David L. (1891; 1892), Pres., United Engrg. and Contr. Co., Managing Dir., Cuban Engrg. and Contr. Co., 17 W. 42d St., New York, N. Y.

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LANE, Francis W. (Associate, 1900), 537 W. 67th St., Chicago, Ill.

LEWIS, Joseph E. (Junior, 1899), Treas., Bush Mfg. Co., and *for mail,* 33 Barnard St., Hartford, Conn.

LOUD, Henry S. (1901), Ch. Engr., U. S. Wood Preserving Co., 165 Broadway, New York, N. Y., and *for mail,* Morristown, N. J.

McDEVITT, Frank J. (Junior, 1906). V. P. and Mgr., Ohio Steam Specialty Co., and *for mail,* 1011 Mahoning Ave., Youngstown, O.

McGREGOR, Alexander Grant (Junior, 1905), 118 T St., Salt Lake City, Utah.

McKECHNIE, Robert R. (1897), South Euclid, O.

MAGIN, Frank W. (Junior, 1907), Allis-Chalmers Co., 71 Broadway, New York, N. Y.

MEAKER, Guy Larnard (Junior, 1904), Asst. Supt., Am. Steel Wire Co., Rockdale Wks., and *for mail,* 216 Grover St., Joliet, Ill.

METZ, Walter R. (Junior, 1902), Supt. of Bldgs., Govt. Ptg. Office, and *for mail,* 211 A St., N. E., Washington, D. C.

MILNE, James (1907), 23 7th Ave., W., Vancouver, B. C., Canada.

MORGAN, John R. (1901), Genl. Mgr., Calumet Engrg. Wks., Harvey, and 1838 W. 99th St., Walden, Chicago, Ill.

MORLEY, Ralph (Junior, 1906), Mech. Engr., Transmission Dept., The Fairbanks Co., New York, and *for mail,* 563 9th St., Brooklyn, N. Y.

MORRISON, Herbert H. (1898; 1904), Cons. Engr., Syndicate Trust Bldg., St. Louis, Mo.

MUNBY, Ernest J. (1906), 208 W. 59th St., New York, N. Y.

NAYLOR, Chas. Wm. (1905), Ch. Engr., Marshall Field & Co., 83 State St., and *for mail,* 2275 Congress St., Chicago, Ill.

NEWBURY, George K. (Junior, 1904), Mgr. Plate Dept., Newbury Mchy. Co., 304 Century Bldg., Denver, Colo.

NOBLE, Alfred (1907), Civil Engr., 7 E. 42d St., New York, N. Y.

OWEN, Ira June (Junior, 1905), Cons. Engr., 855–7 First Natl. Bank Bldg., Chicago, and 110 Maple Ave., Oak Park, Ill.

PATTERSON, A. W., Jr. (1897; 1903), 409 P. O. Sq. Bldg., Boston, Mass.

PEARSON, Walter Ambrose (1907), Rio de Janeiro Tramway, Light and Power Co., Ltd., Avenida Central, 76, Rio de Janeiro, Brazil, South America.

POSSELT, Ejnar (Junior, 1907), Mech. Engr. and Asst. Mgr., St. Louis Portland Cement Wks., and *for mail,* Hotel Berlin, St. Louis, Mo.

POWEL, Samuel W. (1880), Asst. Mech. Engr., Am. Radiator Co., care Pierce Plant, and *for mail,* 679 Auburn Ave., Buffalo, N. Y.

RANDALL, Dwight T. (1904), A. D. Little Co., 93 Broad St., Boston, Mass.

RIPPEY, S. Howard (1904; 1905), Cons. Engr., Sellers & Rippey, 1301 Stephen Girard Bldg., Philadelphia, Pa.

RUGGLES, Wm. Barker (1905), Pres., Ruggles-Coles Engrg. Co., 50 Church St., New York, N. Y., and 91 W. 5th St., Bayonne, N. J.

ST. CLAIR, James Thorpe (Junior, 1901), 5821 Clemens Ave., St. Louis, Mo.

SAGUE, Samuel R. (Junior, 1908), Sales Engr., Power House Equip., Strong, Carlisle & Hammond Co., and *for mail,* 79 Belmore Rd., Cleveland, O.

SHALLENBERGER, Louis R. (1895; 1902), 239 Maple Ave., Oak Park, Ill.

SHEPHERD, Wm. G. (1890; 1904), V. P. and Genl. Mgr., Shepherd Engrg. Co., Williamsport, Pa.

SMEAD, William H. (Junior, 1906), P. O. Box 699, Atlanta, Ga.

SNOW, Sylvester M. (1890), Snow & Humphreys, Room 62, 85 Water St., Boston, Mass., and *for mail,* 257 Gano St., East Side Sta., Providence, R. I.

SPIRO, Charles (1908), Genl. Mgr., Columbia Typewriter Mfg. Co., and *for mail,* 10 W. 121st St., New York, N. Y.

STEARNS, Albert (1880), Supt., Church & Dwight Co., 1406–1446 Willis Ave., and 329 James St., and *for mail,* P. O. Box 74, Syracuse, N. Y.

SYMONS, Wilson E. (1899), Supt. M. P. and Mchy., Chicago Great Western Ry., Met. Opera House Blk., St. Paul, Minn.

TAKEO, Toshisuke (1908), Genl. Mgr., Karatau Iron Wks., Nishikaratsu, Hizen, Japan.

THULLEN, L. H. (1905), Mech. and Elec. Engr., 96 William St., East Orange, N. J.

VANDERBILT, Aaron (1880; 1884; 1908), Life member; Westhampton, L. I., N. Y.

VAN WINKLE, Edward (1904; 1908), Cons. Pat. Engr., West St. Bldg., Cedar and West Sts., New York, and The Stuyvesant, 483 Park Pl., Brooklyn. N. Y.

VON PHILP, C. (1890), Mgr. Mchy. Dept., Bethlehem Steel Co., South Bethlehem, Pa.

WEST, Thos. D. (1884), West Steel and Iron Casting Co., E. 70th St., Cleveland, O.

WESTON, Frederick W. (Associate, 1907), Rep. Baldwin Loco. Wks., Standard Steel Wks. Co., 50 Church St., and 14 W. 48th St., New York, N. Y.

WILCOX, Perley Smith (Junior, 1899), Asst. Mgr. Kodak Part Wks., Eastman Kodak Co., and *for mail,* 10 Audubon St., Rochester, N. Y.

WILLIAMS, Ernest D. (Junior, 1905), Turbine Dept., Genl. Elec. Co., and *for mail,* 1306 Union St., Schenectady, N. Y.

WRIGHT, Reginald A. (1907), Ch. Draftsman, Phila. & Reading Coal and Iron Co., and *for mail,* Y. M. C. A. Bldg., Pottsville, Pa.

NEW MEMBERS

ALDRICH, Chester S. (Junior, 1909), Managing Partner, Gray-Aldrich Co., 7 Commercial Wharf, Boston, Mass.

ALGER, Harley C. (Junior, 1908), Supt., Willcox Engrg. Co., and *for mail,* 300 Simonean St., Saginaw, Mich.

AYERS, Norwood B. (1908), Ch. Engr., Dayton Lighting Co., 124 E. 4th St., and 422 Summers St., Dayton, O.

BABBITT, Edward F. (1909), Engr. with F. L. Packard, Arch., and *for mail,* 406 S. Ohio Ave., Columbus, O.

BEHREND, Bernard A. (1909), Elec. and Mech. Engr., 5754 Howe St., E.E., Pittsburg, Pa.

BLUMGARDT, Isaac E. (Associate, 1908), 501 W. 143d St., New York, N. Y.

BOND, Francis M. (Junior, 1909), Forest Service, Washington, D. C.

BROWN, John Rowland (1900; 1904; 1909), Mech. Engr., Ohio Brass Co., Mansfield, O.

BRUCKNER, Rudolph E. (1909), Ch. Engr., Commercial Acetylene Co., 80 Broadway, New York, N. Y.

BUMP, Archie Edmund (Associate, 1908), Mgr. Constr. Dept., Swift & Co., 34 N. Market St., Boston, Mass.

BUSHNELL, Douglas S. (1909), Genl. Supt., Natl. Transit Co., 26 Broadway, New York, N. Y.

CARPENTER, Allan O. (Associate, 1909), Ch. Draftsman, Chicago Pneumatic Tool Co., and *for mail*, Box 271, Franklin, Pa.

CROCKARD, Frank H. (1909), V. P. and Genl. Mgr., Tenn. Coal, Iron and R. R. Co., Birmingham, Ala.

DISERENS, Paul (Junior, 1908), Research Asst., Univ. of Ill., and *for mail*, 203 W. Green St., Urbana, Ill.

DUNCAN, Albert Greene (1909), Treas., Chicopee Mfg. Co., and *for mail*, 70 Kilby St., Boston, Mass.

ENNIS, J. B. (1909), Asst. to Mech. Engr., Am. Loco. Co., 50 Church St., New York, N. Y., and *for mail*, 615 E. 24th St., Paterson, N. J.

FESSENDEN, Chas. Horace (Junior, 1909), Instr. Mech. Engrg., Univ. of Mich., Room 225, New Engrg. Bldg., Ann Arbor, Mich.

HAMILTON, Chester B., Jr. (Junior, 1909), Draftsman, 43 Madison Ave., Toronto, Ont., Canada.

HART, Robert W. (Associate, 1909), New England Mgr., Olds Gas Power Co., Boston, and 11 Glengarry, Winchester, Mass.

HEM, H. O. (1909), V. P. and Supt., H. N. Strait Mfg. Co., and 721 W. 18th St., Kansas City, Mo.

HOGUE, Oliver D. (1909), Mgr., Power Pump Dept., Goulds Mfg. Co., 1106 Tremont Bldg., Boston, Mass.

HUNTER, John A. (1909), Steam Engr., Am. Sheet and Tin Plate Co., Pittsburg, and *for mail*, 553 Mifflin Ave., Wilkinsburg, Pa.

JEWETT, Arthur C. (1909), Prof. Mech. Engrg., Univ. of Maine, Orono, Me.

JONES, Walter I. (1909), Cons. Engr., 60 Wall St., New York, N. Y.

KELLOGG, Harry F. (1909), Mech. Engr., Chicago, New York & Boston Refrigerator Co., and *for mail*, 5431 Jefferson Ave., Chicago, Ill.

KESSLER, Armin Geo. (Junior, 1909), Instr., Sibley College, Cornell Univ., and *for mail*, 805 E. State St., Ithaca, N. Y.

KING, Geo. Caryl (1908), Asst. Genl. Mgr. and Mech. Engr., Union Irrigation Co., and *for mail*, P. O. Box 133, Washington, La.

KNIGHT, Alfred H. (1909), Asst. Prof. Mech. Engrg., Univ. of Mich., and 1105 Oakland Ave., Ann Arbor, Mich.

LEE, Ralph A. (Junior, 1909), Mech. Draftsman, 414 78th St., Brooklyn, N. Y.

MAXWELL, Max Carson (1908), Head Instr. Applied Mech., Pratt Inst., Brooklyn. N. Y.

PECK, Eugene C. (1909), Genl. Supt., Cleveland Twist Drill Co., and 1242 E. 49th St., Cleveland, O.

PELLISSIER, George E. (Associate, 1909), Ch. Engr., Goldschmidt Thermit Co., 90 West St., and 510 W. 143d St., New York, N. Y.

PHELPS, Charles C. (Junior, 1909), Gage Pub. Co., 114 Liberty St., New York, N. Y.

PLUNKETT, Charles T. (1909), V. P. and Secy., Berkshire Cotton Mfg. Co., Adams, Mass.

PUCHTA, Edward (1909), Asst. Supt., Western Elec. Co., 48th Ave. and W. 24th St., and *for mail,* 59 Buena Ave., Chicago, Ill.

PULIS, Wm. Eugene (Junior, 1909), Industrial Engr., Sayles Bleacheries, and *for mail,* P. O. Box 11, Saylesville, R. I.

RICHARDSON, Levi S. (1909), Draftsman, N. Y. Edison Co., New York, and *for mail,* Rosebank, S. I., N. Y.

RILEY, Joseph C. (1909), Asst. Prof. Mech. Engrg., Mass. Inst. of Tech., Boston, Mass.

SEARLE, Wilbur C. (Junior, 1909), Heald Mch. Co., and *for mail,* 10 Townsend St., Worcester, Mass.

SHENBERGER, Geo. H. (Junior, 1909), Draftsman, Lehigh Coal and Navigation Co., and *for mail,* Lansford, Pa.

SMITH, Carl D. (Junior, 1909), Asst. Engr., Tech. Branch, U. S. Geolog. Survey, 40th and Butler Sts., Pittsburg, Pa.

STANTON, Alden D. (Junior, 1909), Ch. Draftsman, Dept. Bldgs. and Grounds, Columbia Univ., New York, and *for mail,* 378 Greene Ave., Brooklyn, N. Y.

TAYLOR, John W. (Junior, 1909), Ch. Draftsman, Russell Eng. Co., and *for mail,* 88 3d St., Massillon, O.

THOMPSON, Edward C. (Junior, 1909), Mech. Engr. and Mgr., C. W. Traner Mfg. Co., and *for mail,* 89 Pearl St., Boston, Mass.

THOMPSON, Sanford E. (1909), Cons. Engr., Newton Highlands, Mass.

THURSTON, Edward D., Jr., (Junior, 1909), Asst. Dept. Mech. Engrg., Columbia Univ., and *for mail,* 617 W. 113th St., New York, N. Y.

TIPLADY, John T. (1909), Supt. Mch. and Power Plant, Variety Iron and Steel Wks. Co., Cleveland, O.

TUTTLE, Irving E. (Junior, 1909), Mech. Draftsman, Westinghouse, Church, Kerr & Co., New York, and *for mail,* 198 Greene Ave., Brooklyn, N. Y.

WHITING, Richard A. (Junior, 1909), Instr. Exper. Engrg., Stevens Inst., Hoboken, N. J., and *for mail,* 137 W. 117th St., New York, N. Y.

WILLS, C. Harold (1909), Ch. Engr. and Factory Mgr., Ford Motor Co., and *for mail,* 39 Bethune Ave., W., Detroit, Mich.

WILLSON, Ernest M. (Associate, 1909), Ch. Draftsman, Hart-Parr Co., and *for mail,* 601 Wisconsin St., Charles City, Ia.

WOOLLEY, Harold O. (Junior, 1909), Draftsman, Power Specialty Co., Dansville, N. Y.

PROMOTIONS

CASTANEDO, Walter (1907; 1909), Member of Firm, Glenny & Castanedo, 1125–27 Maison Blanche Bldg., and *for mail,* 1514 Peters Ave., New Orleans, La.

CHATARD, Wm. Miles (1903; 1909), Dist. Mgr., Carbondale Mch. Co., 1412 Continental Bldg., and 5 W. Chase St., Baltimore, Md.

DALE, Orton G. (1894; 1909), Mgr., Mead-Morrison Mfg. Co., 11 Broadway, New York, N. Y., and Plainfield, N. J.

DILLARD, James B. (1907; Associate, 1909), Capt. Ordnance Dept., War Dept., Washington, D. C.

HUNTER, James Francis (1899; 1909), Asst. Engr. of Constr., Cons. Gas Co., 4 Irving Pl., New York, N. Y., and 1517 Bolton St., Baltimore, Md.

IDELL, Percy C. (1901; Associate, 1909), Sales Dept., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y., and *for mail,* 1026 Hudson St., Hoboken, N. J.

KILGOUR, Dwight F. (1905; 1909), Mech. Engr., Chas. E. Cotting, Trustee, 11 Pemberton Sq., Boston, Mass.

POMEROY, L. R. (1890; 1909), Asst. to Pres., Safety Car Heating and Lighting Co., 2 Rector St., New York, N. Y., and 24 Reynolds Terrace, Orange, N. J.

ROBINSON, Garland P. (1902; 1909), Pub. Service Com., 2d Dist., Albany, N. Y.

WHITTED, Thomas B. (1900; 1903; 1909), Pres., Thomas B. Whitted & Co., Contr. Engrs., Piedmont Bldg., and 317 W. 5th St., Charlotte, N. C.

DEATHS

CALDWELL, Andrew J.

GAS POWER SECTION

CHANGES OF ADDRESS

DAWLEY, Clarence A. (1908), Cons. Engr., 323 W. 77th St., New York, N. Y.

HOWARD, Chas. Alton (1908), E. W. Bliss Co., Adams and Plymouth Sts., Brooklyn, and *for mail,* 519 W. 124th St., New York, N. Y.

MORLEY, Ralph (1908), Mech. Engr., Transmission Dept., The Fairbanks Co., New York, and *for mail,* 563 9th St., Brooklyn, N. Y.

MORRISON, Herbert H. (1908), Cons. Engr., Syndicate Trust Bldg., St. Louis Mo.

THULLEN, L. H. (1908), Mech. and Elec. Engr., 96 William St., East Orange, N. J.

VAN WINKLE, Edward (1908), Cons. Pat. Engr., West St. Bldg., Cedar and West Sts., New York, and The Stuyvesant, 483 Park Pl., Brooklyn, N. Y.

VERKOUTEREN, A. J. (Affiliate, 1908), Cons. Engr., 35 Richelieu Terrace, Newark, N. J.

NEW MEMBERS

BAILY, Thaddeus F. (Affiliate, 1909), Genl. Mgr. and Engr., Baily Eng. Co., Alliance, O.

BALLIN, Alfred Edward (1909), Asst. Ch. Engr., Snow Steam Pump Wks., and 188 W. Utica St., Buffalo, N. Y.

BULMER, Wm. Carr (Affiliate, 1909), 525 Division Ave., Ann Arbor, Mich.

COLE, Arthur W. (1909), Instr. Mech. Engrg., Purdue Univ., Lafayette, and *for mail.* 224 Waldron St., West Lafayette. Ind.

DOW, Benjamin W. (Affiliate, 1909), 7 Standish St., Dorchester, Mass.

ENGLISH, Harry K. (1909), Box 688, Gary, Ind.

FAIRFIELD, Howard P. (1909), Instr., Worcester Poly. Inst., and *for mail,* 25 John St., Worcester, Mass.

FULLER, Edgar H. (Affiliate, 1909), Sales Mgr., Root & Van Dervoort Engrg. Co., East Moline, Ill.

GOLDINGHAM, Arthur H. (1909), De La Vergne Mch. Co., Foot E. 138th St., and *for mail,* 457 W. 123d St., New York, N. Y.

GORE, Warren W. (1909), V.P., Gas Power Mfg. Co., Seattle, and *for mail,* 1610 Main St., Olympia, Washington.

GRAVES, Carleton A. (Affiliate, 1909), Power Engr., Edison Elec. Co., 360 Pearl St., Brooklyn, N. Y.

LANG, Charles (1909), N. Y. Mgr., C. H. Wheeler Mfg. Co., 114 Liberty St., New York, and 348 Jefferson Ave., Brooklyn, N. Y.

LUTHER, Stephen G. (1909), Asst. Ch. Draftsman, Gas Eng. Dept., Snow Steam Pump Wks., and *for mail,* 469 Prospect Ave., Buffalo, N. Y.

MACNEILL, M. B. (Affiliate, 1909), Hyd. Engr., Watson-Stillman Co., New York, N. Y., and *for mail*, 251 North Ave., W., Cranford, N. J.

MORDEN, Charles W. (Affiliate, 1909), 206 West St., Worcester, Mass.

MUNRO, George W. (Affiliate, 1909), Purdue Univ., Lafayette, Ind.

PARKER, Charles H. (1909), Asst. Supt. Generating Dept., Boston Edison Co., 3 Head Pl., and 260 Clarendon St., Boston, Mass.

PERCY, Earle N. (1909), Engr., Imperial Gas Eng. Co., and *for mail*, 3570 Clay St., San Francisco, Cal.

PIERSON, Robert M. (Affiliate, 1909), Pat. Solicitor, 149 Broadway, New York, N. Y.

ROBINSON, Edward P. (1909), Supt., Atlantic Wks., 80 Border St., East Boston, Mass.

SOUTHWORTH, Martin O. (1909), Elec. Engr., Fairbanks, Morse & Co., 481 Wabash Ave., and *for mail*, Hotel Windemere, Chicago, Ill.

THOMPSON, Wm. K. (Affiliate, 1909), Secy., Western Gas Eng. Co., 908 N. Main St., Los Angeles, Cal.

WARMAN, William A. (1909), Supt. and Designer, Keller Mech. Engr. Co., 570 W. Broadway, New York, N. Y.

COMING MEETINGS

Secretaries or members of societies whose meetings are of interest to engineers are invited to send in their notices for publication in this department. Such notices should be in the editor's hands by the 15th of the month preceding the meeting.

AËRONAUTIC SOCIETY
June 16, etc., evenings, weekly meetings, Automobile Club of America, W. 54th St., New York. Secy., Wilbur R. Kimball.

AMERICAN BOILER MANUFACTURERS ASSOCIATION
August 10–12, Hotel Ponchartrain, Detroit, Mich. Secy., J. D. Farasey, E. 37th St. and Erie Ry., Cleveland, O.

AMERICAN CHEMICAL SOCIETY
June 29–July 2, Detroit, Mich. Secy., Chas. L. Parsons, Durham, N. H.

AMERICAN GAS POWER ASSOCIATION
July 22, quarterly meeting, Minneapolis, Minn. Secy., R. P. Gillette.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
June 24–25, semi-annual meeting, Polytechnic Institute, Brooklyn, N. Y. Papers: The Utilization of Low Grade Fuels in the United States, O. K. Zwingneberger; Creosote Oil from Coal Gas Tar, S. P. Sadtler; Automatic Acid Egg, Richard K. Meade; Some Experiments on Case Hardening of Steel with Gases, J. C. Olsen; New York Metropolitan District as a Center for Great Industries, C. F. McKenna; Methods of Clay Control, J. G. Dean. Secy., J. C. Olsen.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
June 28, Annual Convention, Frontenac, N. Y. Secy., Ralph W. Pope, 33 W. 39th St., N. Y.

AMERICAN PORTLAND CEMENT MANUFACTURERS
July 13, quarterly meeting, Philadelphia, Pa. Secy., Percy H. Wilson, Land Title Bldg.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION
June 16–18, Annual Convention, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY OF CIVIL ENGINEERS
June 16, September 1, semi-monthly meetings, 220 W. 57th St., New York, July 6–9, Annual Convention, Mt. Washington Hotel, Bretton Woods, N. H. Secy., C. W. Hunt.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
July 15, 16, summer meeting, Indianapolis, Ind. Secy., W. M. Mackay, P. O. Box 1818, New York.

AMERICAN SOCIETY OF HUNGARIAN ENGINEERS AND ARCHITECTS
June 5, 29 W. 39th St., New York, 8.30 p.m. Secy., Zoltan de Németh, 103 E. 16th St.

AMERICAN SOCIETY OF SWEDISH ENGINEERS
September 4, semi-monthly meeting, Brooklyn, N. Y. Secy., E. Hammerstrom, 271 Hicks St.

AMERICAN SOCIETY FOR TESTING MATERIALS
June 29–July 3, annual meeting, Hotel Traymore, Atlantic City, N. J. Secy., Edgar Marburg, Univ. of Penna., Philadelphia, Pa.

AMERICAN WATER WORKS ASSOCIATION
June 8–12, Annual Convention, Milwaukee, Wis. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ASSOCIATION OF CAR LIGHTING ENGINEERS
June 7, semi-annual meeting, New York. Secy., G. B. Colegrove, 6250 Drexel Ave., Chicago, Ill.

ASSOCIATION OF RAILWAY CLUB SECRETARIES
June 19, annual meeting, Atlantic City, N. J.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS
June 23–25, Detroit, Mich. Secy., P. W. Drew, Room 511, Harvester Bldg., Chicago, Ill.

BLUE ROOM ENGINEERING SOCIETY
July 1, August 5, monthly meetings, 29 W. 39th St., New York, 8 p.m. Secy., W. D. Sprague.

BOSTON SOCIETY OF CIVIL ENGINEERS
June 16, monthly meeting, Tremont Temple. Secy., S. E. Tinkham, 60 City Hall.

BROOKLYN ENGINEERS' CLUB
June 3, 117 Remsen St. Paper: Gas Engines, Geo. A. Orrok. June 10, Machinery Club, 50 Church St. Secy., Joseph Strachan.

CANADIAN ELECTRICAL ASSOCIATION
June 16–18, annual Convention, Quebec. Secy., T. S. Young, Confederation Life Bldg., Toronto.

CANADIAN FREIGHT ASSOCIATION
July 15, quarterly meeting, Secy., T. Marshall, Toronto.

CANADIAN GAS ASSOCIATION
June 25, annual meeting, Toronto, Ont. Secy., A. W. Moore, Woodstock.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION
September, annual meeting. Secy., F. P. Wilson, 405 Confederation Life Bldg., Toronto.

CANADIAN RAILWAY CLUB
September 7, monthly meeting, 8 p.m., Windsor Hotel, Montreal, Que. Secy , Jas. Powell, St. Lambert, P. Q.

CAR FOREMEN'S ASSOCIATION OF CHICAGO
June 14, monthly meeting, Masonic Temple. Secy., Aaron Kline, 326 N. 50th St.

CENTRAL RAILWAY CLUB.
September 10, Hotel Iroquois, Buffalo, N. Y., 8 p. m. Secy., H. D. Vought, 95 Liberty Street, New York.

COLORADO SCIENTIFIC SOCIETY
July 3, monthly meeting, Denver. Secy., Dr. W. A. Johnston, 801 Symes Bldg.

DENVER SOCIETY OF CIVIL ENGINEERS
June 8, monthly meeting, 36 Jacobson Bldg. Secy., Walter Pearl.

ELECTRIC CLUB OF CHICAGO
June 16, etc., weekly meetings, noon, Chicago Automobile Club. Secy., W. S. Taussig, Marquette Bldg.

ENGINEERING ASSOCIATION OF THE SOUTH
June 15, monthly meeting. Secy., H. M. Jones, 2 Berry Blk., Nashville, Tenn.

ENGINEERS AND ARCHITECTS' CLUB OF LOUISVILLE, KY.
June 21, monthly meeting, 303 Norton Bldg. Secy., Pierce Butler.

ENGINEERS' CLUB OF CENTRAL PENNSYLVANIA
September 7, monthly meeting, Gilbert Bldg., Harrisburg. Secy., E. R. Dasher.

ENGINEERS' CLUB OF CINCINNATI
June 17, monthly meeting, 25 E. 8th St. Secy., E. A. Gast, P. O. Box 333.

ENGINEERS' CLUB OF MINNEAPOLIS
June 21, July 19, August 16, monthly meetings, City Hall.

ENGINEERS' CLUB OF PHILADELPHIA
September 4, etc., semi-monthly meetings, 1122 Girard St. Secy., W. P. Taylor.

ENGINEERS' CLUB OF ST. LOUIS
June 16, September 1, semi-monthly meetings, 3817 Olive St. Secy., R. H. Fernald.

ENGINEERS' CLUB OF TORONTO
June 17, 24, September 2, etc., weekly meetings, 96 King St., W. Secy., R. B. Woolsey.

ENGINEERS' SOCIETY OF MILWAUKEE
June 9, annual meeting, September 8, monthly meeting, 456 Broadway. Secy., W. Fay Martin.

ENGINEERS' SOCIETY OF PENNSYLVANIA
June 15, regular meeting, September 7, section meeting. Secy., E. K. Hiles, 803 Fulton Bldg., Pittsburgh, Pa.

FREIGHT CLAIM ASSOCIATION
June 16, annual meeting, Old Point Comfort, Va. Secy., W. P. Taylor, Richmond, Va.

INTERNAL COMBUSTION ENGINEERS ASSOCIATION
June 11, July 9, August 13, monthly meetings, Sherman House, Chicago, Ill. Secy., H. R. Linn, 61 Ward St.

INTERNATIONAL ACETYLENE ASSOCIATION
August 9–11, annual meeting, Hotel Knickerbocker, New York. Secy., A. Cressy Morrison, 157 Michigan Ave., Chicago, Ill.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS
August 17–20, Grand Rapids, Mich. Secy., Jas. McFall, Roanoke, Va.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION
August 18, Niagara Falls, N. Y. Secy., A. L. Woodworth, Lima, O.

INTERNATIONAL RAILWAY FUEL ASSOCIATION
June 21–23, annual meeting, Auditorium Hotel, Chicago, Ill. Secy., D. B. Sebastian, 327 La Salle St. Sta., Chicago.

IOWA DISTRICT GAS ASSOCIATION

June 23–25, annual meeting, Waterloo, Ia. Secy., G. I. Vincent, Des Moines.

IOWA RAILWAY CLUB

June 11, September 10, Union Sta., Des Moines. Secy., W. B. Harrison.

LOUISIANA ENGINEERING SOCIETY

June 14, monthly meeting, 321 Hibernia Bldg., New Orleans. Secy., L. C. Datz.

MASSACHUSETTS STREET RAILWAY ASSOCIATION

September 8, Young's Hotel, Boston. Secy., Chas. S. Clark, 70 Kilby St.

MASTER CAR BUILDERS' ASSOCIATION

June 21–23, annual Convention, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER MECHANICS ASSOCIATION

June, Convention, Atlantic City, N. J.

MODERN SCIENCE CLUB

June 13, etc., weekly meetings, 125 S. Elliott Pl., Brooklyn, N. Y. Secy., Jas. A. Donnelly.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

September, annual meeting. Secy., C. J. H. Woodbury, P. O. Box 3672.

NATIONAL ASSOCIATION OF GERMAN-AMERICAN TECHNOLOGISTS

August 28–31, annual meeting, 532 N. 4th St., Philadelphia, Pa. Secy., O. Güssefeldt, 456 Richmond St.

NATIONAL ELECTRIC LIGHT ASSOCIATION

June 1–4, Atlantic City, N. J. Papers: Private Policy, Paul Lüpke; Unique Features in Power Plant Design, G. L. Knight; Low-Pressure Steam Turbines, C. H. Smoot; Compilation of Load Factors, E. W. Lloyd; Electric Power, H. J. Gille; New York High-Pressure Fire System, Arthur Williams; Central Station Operation of Steam Plants in Connection with Central Station Service, S. Morgan Bushnell ; etc. Secy., John F. Gilchrist, 29 W. 39th St., New York.

NATIONAL GAS AND GASOLENE ENGINE TRADES ASSOCIATION

June 22–24, Oliver Hotel, South Bend, Ind. Secy., A. Stritmatter, Cincinnati, Ohio.

NEWARK TECHNOLOGICAL SOCIETY

June 9, 842 Broad St., Newark, N. J. Secy., W. Riehl, 235 N. J. R. R. Ave.

NORTHERN RAILWAY CLUB

June 26, July 24, August 28, monthly meetings, Commercial Club Rooms, Duluth, Minn. Papers: June, Demurrage, its Benefits, Necessity, etc., F. L. Klock; July, Steel vs. Wooden Freight and Passenger Cars, their Relative Cost, their Use and Repairs, etc., W. A. Clark; August, Steel vs. Wooden Ties, W. H. Hoyt. Secy., C. L. Kennedy, 401 W. Superior St.

OHIO ELECTRIC LIGHT ASSOCIATION

July 13–15, annual Convention, Toledo. Secy., D. L. Gaskill, Greenville.

PROVIDENCE ASSOCIATION OF MECHANICAL ENGINEERS

June 22, annual meeting, Alfredian Hall, 123 Eddy St. Secy., T. M. Phetteplace, 48 Snow St.

RENSSELAER SOCIETY OF ENGINEERS

June 18, 257 Broadway, Troy, N. Y. Secy., R. S. Furber.

RICHMOND RAILROAD CLUB

September 13, monthly meeting, 8 p.m. Secy., F. O. Robinson, C. & O. Ry., Richmond, Va.

ROCHESTER ENGINEERING SOCIETY

June 11, July 9, August 13, monthly meetings. Secy., John F. Skinner, 54 City Hall.

ROCKY MOUNTAIN RAILWAY CLUB

June 19, monthly meeting. Secy., J. E. Buell, Denver, Colo.

ST. LOUIS RAILWAY CLUB

September 10, monthly meeting, Southern Hotel, 8 p.m. Secy., B. W. Frauenthal, Union Sta.

SCRANTON ENGINEERS' CLUB

June 17, July 15, August 19, monthly meetings, Board of Trade Rooms. Secy., A. B. Dunning.

SHORT LINE RAILROAD ASSOCIATION

July 13, August 10, 60 Wall St., New York. Secy., John N. Drake.

SOCIETY OF RAILWAY FINANCIAL OFFICERS

September 7, 8, Ft. William Henry, Lake George, N. Y. Secy., C. Norquist, Chicago, Ill.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB

August 19, quarterly meeting, Piedmont Hotel, Atlanta, Ga. Secy., A. J. Merrill.

TECHNICAL SOCIETY OF BALTIMORE

June 19, July 3, 17, August 7, 21, September 4, semi-monthly meetings, 1120 Harford Ave. Secy., Heinrich Türk, 1640 E. Baltimore St.

TECHNICAL SOCIETY OF BROOKLYN

September 3, Arion Hall, Arion Pl., 8.30 p.m. Secy., Oswald Gueth.

TECHNICAL SOCIETY OF CHICAGO

June 23, September 8, semi-monthly meetings, Hotel Bismarck, Randolph St. and 5th Ave. Secy., E. Reutner, 729 S. Millard Ave.

TECHNICAL SOCIETY OF NEW YORK

September 2, monthly meeting, 29 W. 39th St. Secy., Karl Kalbe.

TECHNICAL SOCIETY OF THE PACIFIC COAST

August 6, San Francisco, Cal. Secy., Otto von Geldern, 1978 Broadway.

TECHNICAL SOCIETY OF PHILADELPHIA

June 12, 26, September 11, semi-monthly meetings; July 3, annual meeting, 532 N. 4th St. Secy., O. Güssefeldt, 456 Richmond St.

TECHNICAL SOCIETY OF PITTSBURGH

June 23, September 8, semi-monthly meetings, 8 p.m., 222 Craft Ave. Secy., H. R. Setz.

TECHNICAL SOCIETY OF WASHINGTON

June 16, July 21, August 18, monthly meetings, 314 C St. N. W. Secy., Paul Bausch, 3418 Brown St. N. W.

TECHNOLOGY CLUB OF SYRACUSE

June 9, September 8, 502 Bastable Blk., 8 p.m. Secy., Robert L. Allen.

TRAIN DESPATCHERS' ASSOCIATION OF AMERICA

June 15, annual Convention, Columbus, O. Secy., J. F. Mackie, La Salle St. Sta., Chicago, Ill.

TRAVELING ENGINEERS' ASSOCIATION

September, annual meeting, Denver, Colo. Secy., W. O. Thompson, Oswego, N. Y.

WESTERN CANADA RAILWAY CLUB

September 13, monthly meeting, Royal Alexandra Hotel, Winnipeg, Man. Secy., W. H. Rosevear.

WESTERN SOCIETY OF ENGINEERS

June 16, 1735 Monadnock Bldg., Chicago, Ill. Secy., J. H. Warder.

MEETINGS TO BE HELD IN ENGINEERING SOCIETIES' BUILDING

Date	Society	Secretary	Time
June 15	N. Y. Society Accountants & Bkprs	T. L. Woolhouse	8.00
June 15	New York Telephone Society	T. H. Laurence	8.00
June 22	N. Y. Society Accountants & Bkprs	T. L. Woolhouse	8.00
July 1	Blue Room Engineering Society	W. D. Sprague	8.00
Aug. 5	Blue Room Engineering Society	W. D. Sprague	8.00

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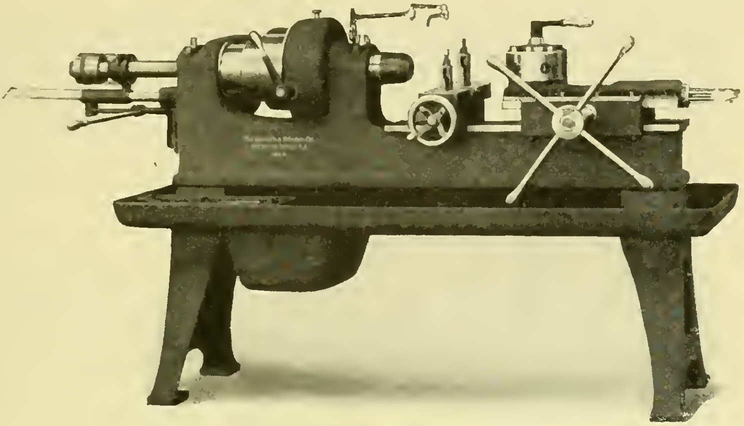

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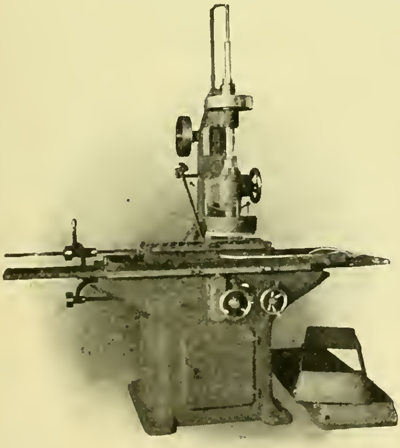

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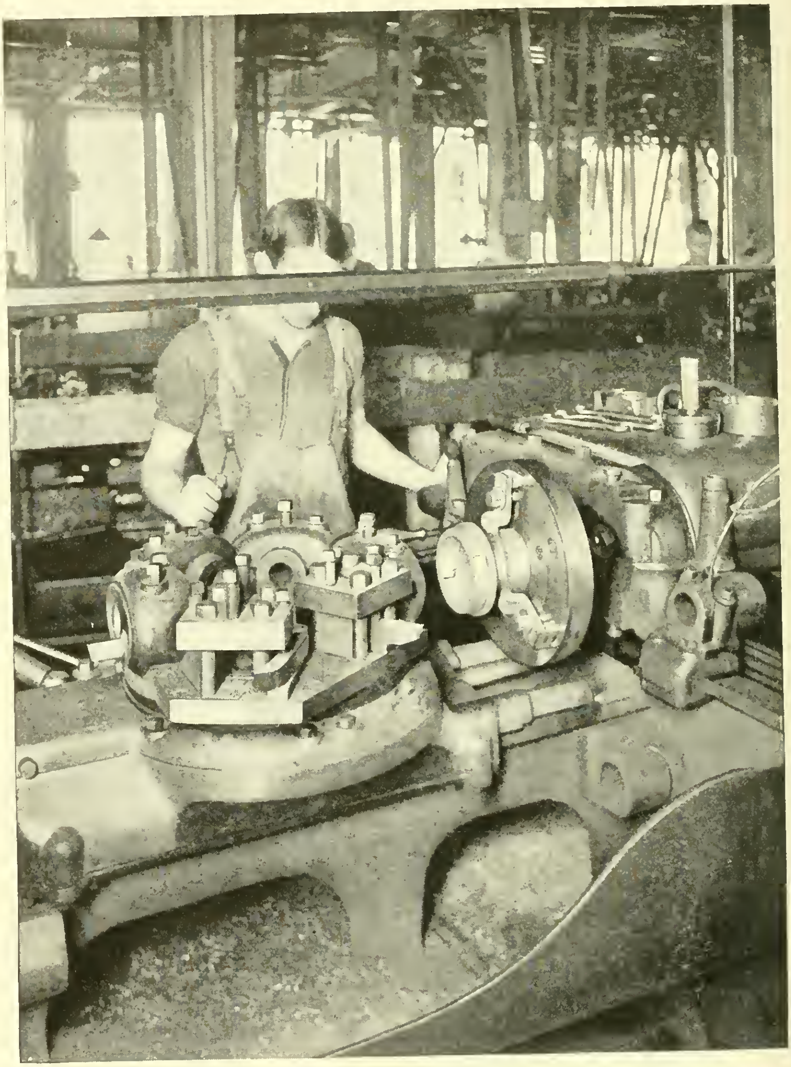

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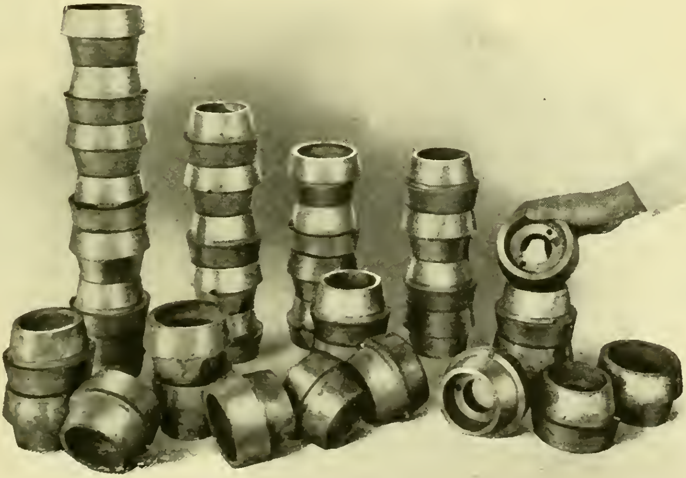

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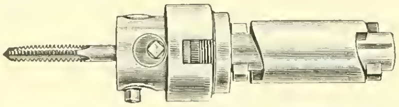
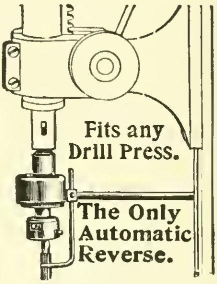


No. 00	Taps to	3/8
No. 0	" "	5/8
No. 1	" "	3/4
No. 2	" "	1
No. 3	" "	1¼
No. 4	" "	1½
No. 5	" "	2

Friction Self-Centering Tap-Holder for Turret Lathe.



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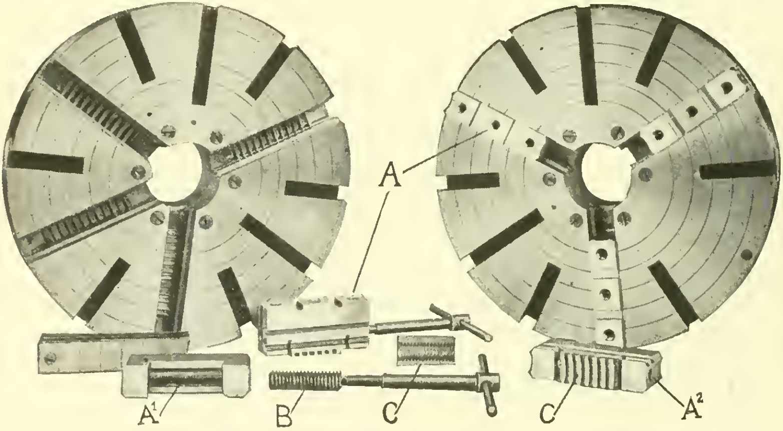

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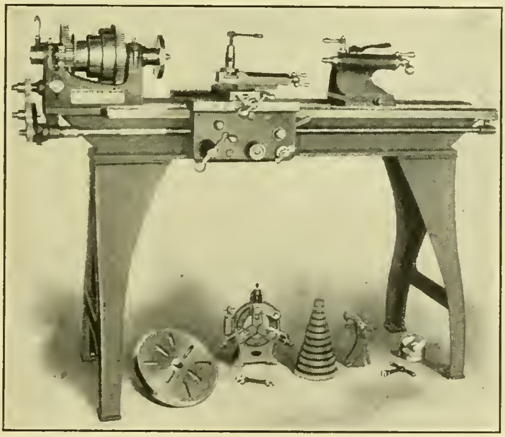

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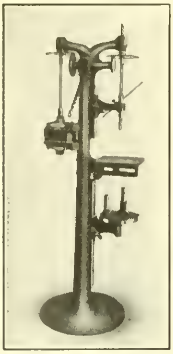

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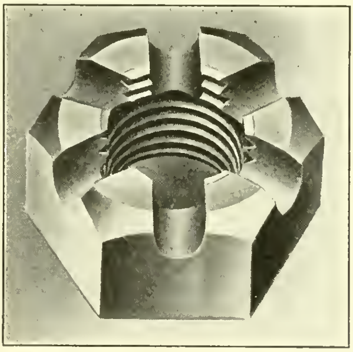

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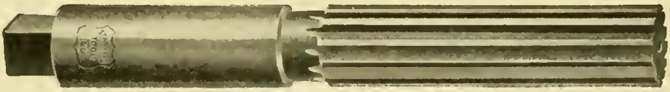

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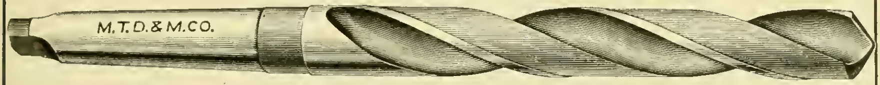

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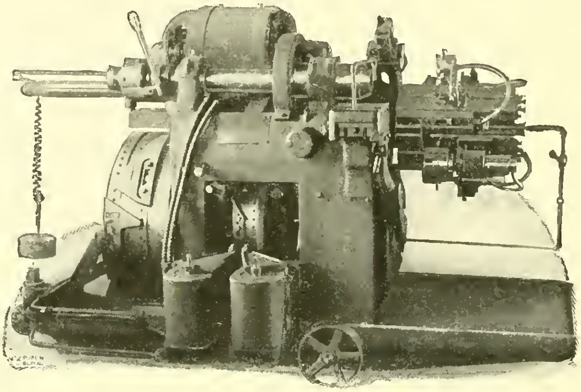

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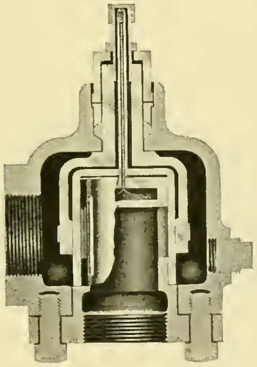

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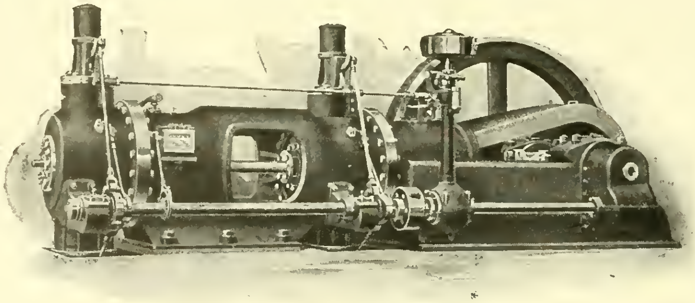

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combustion chamber and water jackets
All valve cages removable

The most reliable and economical motive power obtainable
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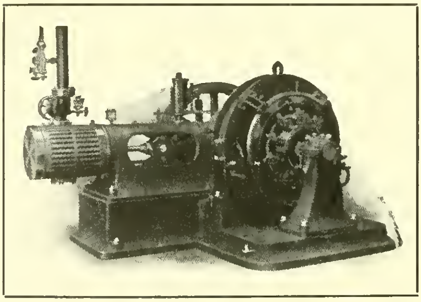
Accessibility of all parts is one feature of our new Side Crank Engine that is much appreciated. There are many others. Bulletins? Ask.



RIDGWAY DYNAMO AND ENGINE CO.

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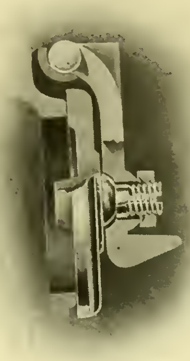
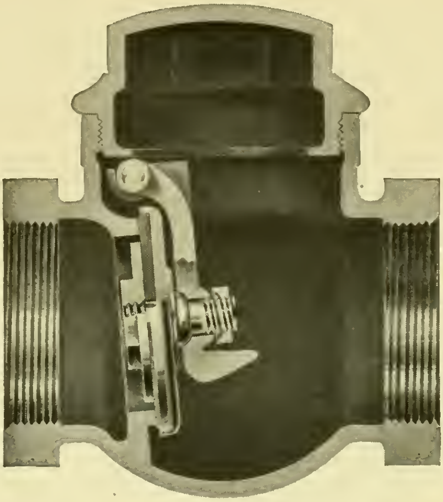


Bronze Disc Mechanism



Sectional view, with Leather Disc

Nelson Bronze Swing Check Valve

We invite comparison of this valve with any other check valve made.

The bronze disc type for steam service is composed of a body, bonnet, disc, self-hinging clapper and disc nut; in the leather disc type for hydraulic work, the leather disc and bronze disc retainer are added.

The body is cast in one piece; the joints or plugs necessary in other check valve bodies are conspicuously absent in this one, in which we have provided a bearing cast in the valve body, on which the disc clapper freely swings with so little friction as to make the wear inappreciable.

The ball-and-socket-jointed disc provides free movement, so that the back pressure makes perfect seating.

When the valve is open the flow is unrestricted to the full capacity of the line; it can be attached in any position; all parts are renewable and interchangeable.

Made for working pressures of 125 and 300 pounds,
each valve tested to 250 and 800 pounds respectively.

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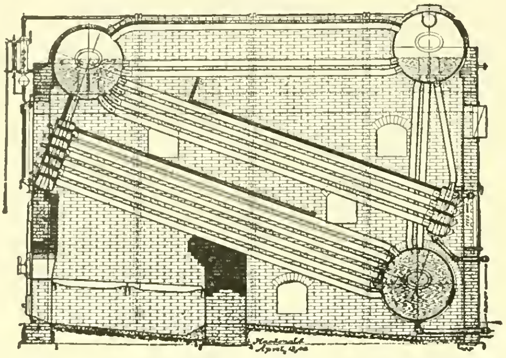

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Perfect water circulation

Dry or superheated Steam

Half the usual number of handholes

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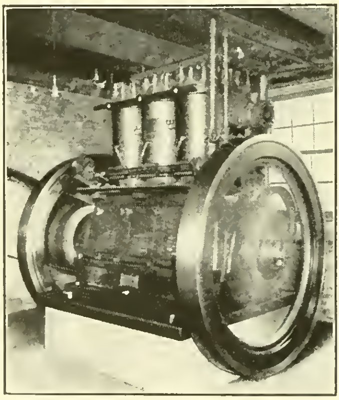

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are simple, economical and reliable, and have demonstrated their superiority in service.

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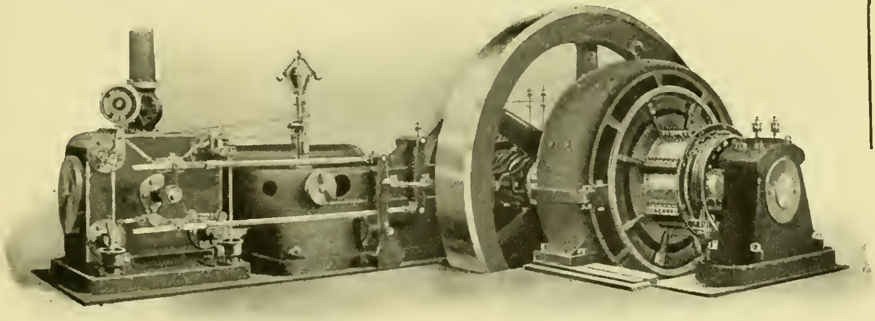

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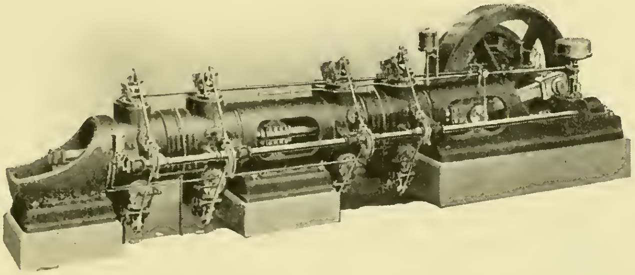

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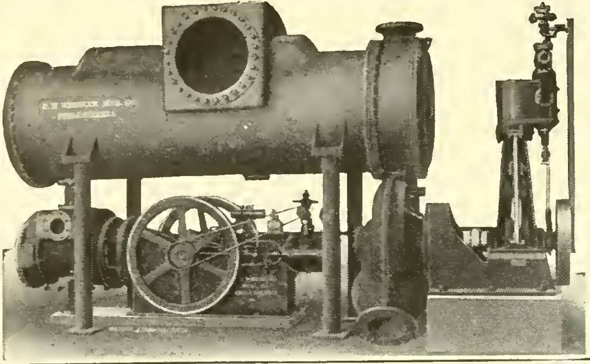

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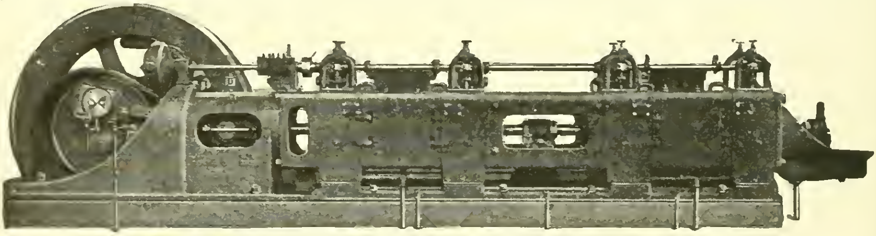

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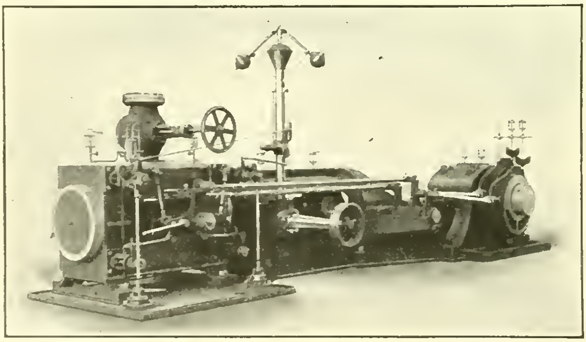
RIVERSIDE ENGINE COMPANY Oil City, Pennsylvania



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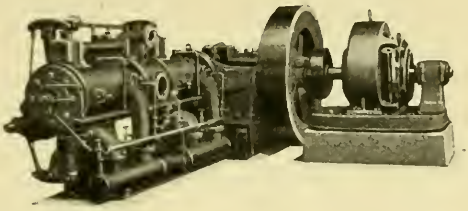

NO matter what kind of power you are using now, it will pay you to know about Du Bois Gas and Gasoline Engines (5 to 375 H.-P.) Catalog "P" explains and illustrates *why* they are better adapted to the special requirements of power plants of all sizes than any other make.

When writing for our catalog, please tell us something about your power requirements and let us "prescribe."

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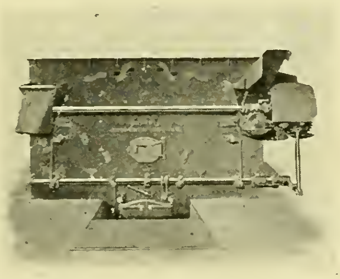

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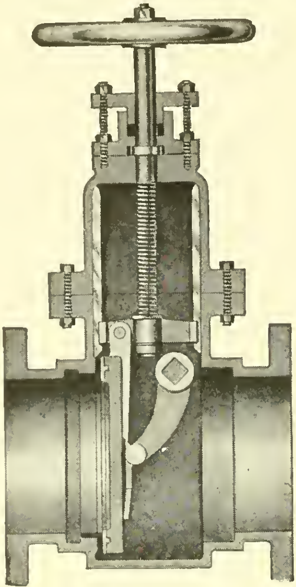

AS A SAFETY RELIEF ON AIR LINES OF COMPRESSORS

The following letter, confirms our claims for the **safety features** of the **ERWOOD Swing Gate Valve** for the above purpose.

Office of Chicago Pneumatic Tool Company.

New York, October 1st, 1907.

Messrs. Walch & Wyeth,
87 E. Lake Street, Chicago, Ill.

Gentlemen:—Referring to sample of your Erwood Swing Gate Valve sent to our Franklin Plant for inspection and test, as arranged, we are pleased to inform you that our test of this valve has demonstrated that it will admirably answer the purpose intended, i. e. automatically relieving the pressure in air discharge lines in case the valve is not open or becomes accidentally closed while the compressor is in operation.

The placing of your valve in the air line between compressor and receiver enables the retention of the compressed air stored in the receiver and piping system when compressor is not running, with assurance that no mishap will occur should compressor be started without opening the check valve between compressor and receiver.

It gives us great pleasure to testify to the merit of your Valve for the service described.

Very respectfully,
W. P. PRESSINGER, Genl. Mgr. Compressor Dept.

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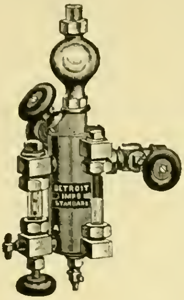

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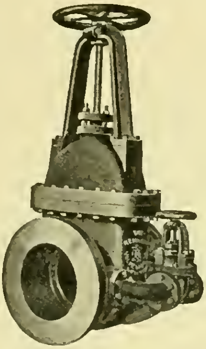

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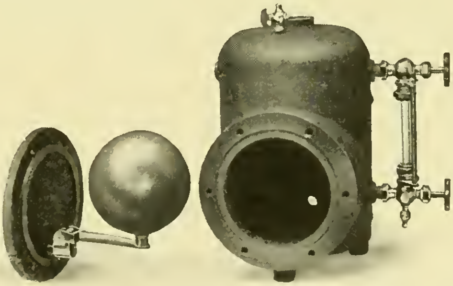

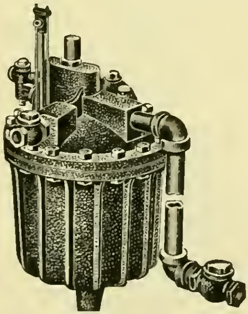

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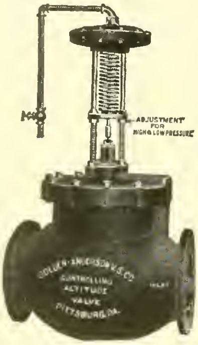
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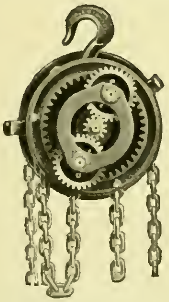

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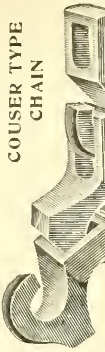

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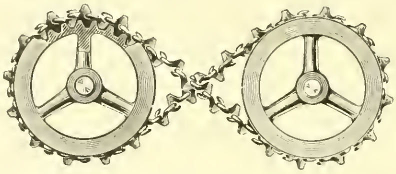

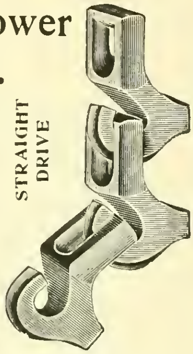

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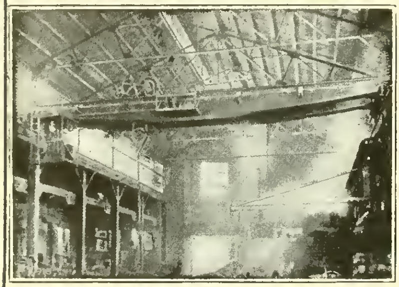

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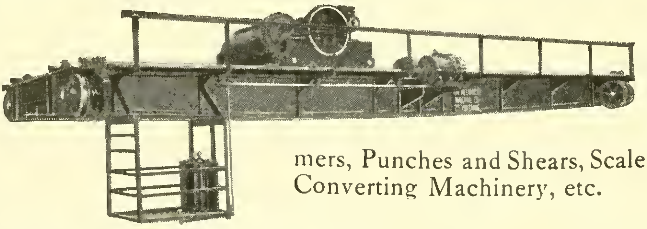

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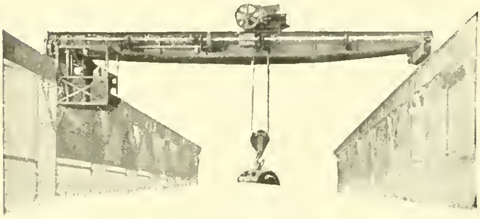

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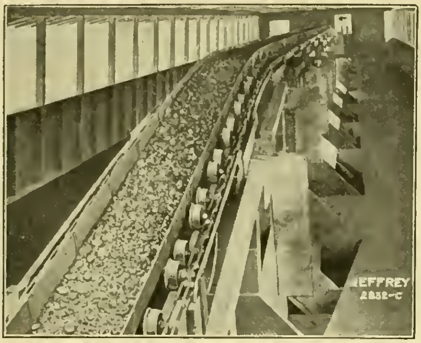

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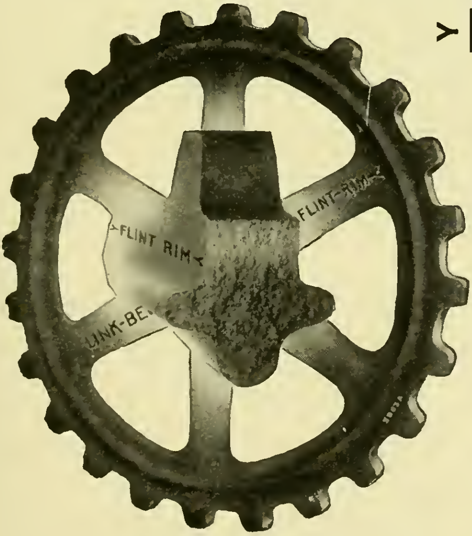

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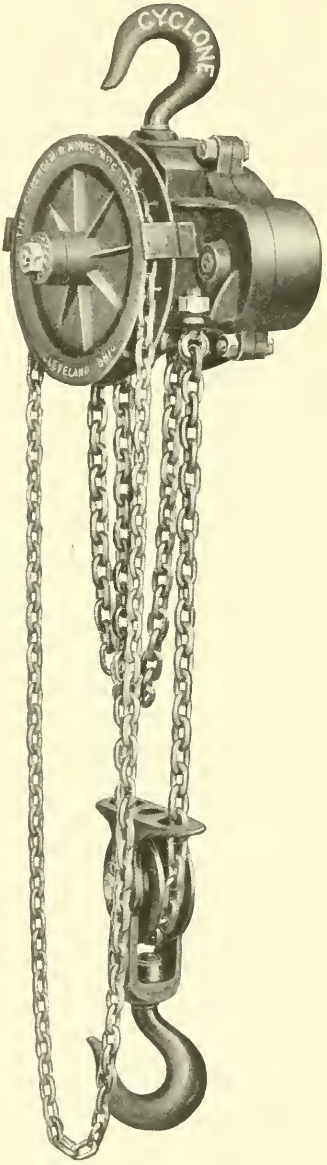

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There is the least possible friction loss, the efficiency averaging nearly 80 per cent. It can therefore be geared to a higher speed than any other hoist with no greater hand wheel pull.

When there is no load the hand wheel may be spun in either direction.

When the hand chain is released the **Automatic Brake** immediately locks the block so that the load is safely held at any point. It may be readily lowered, however, by a reverse pull on the hand chain.

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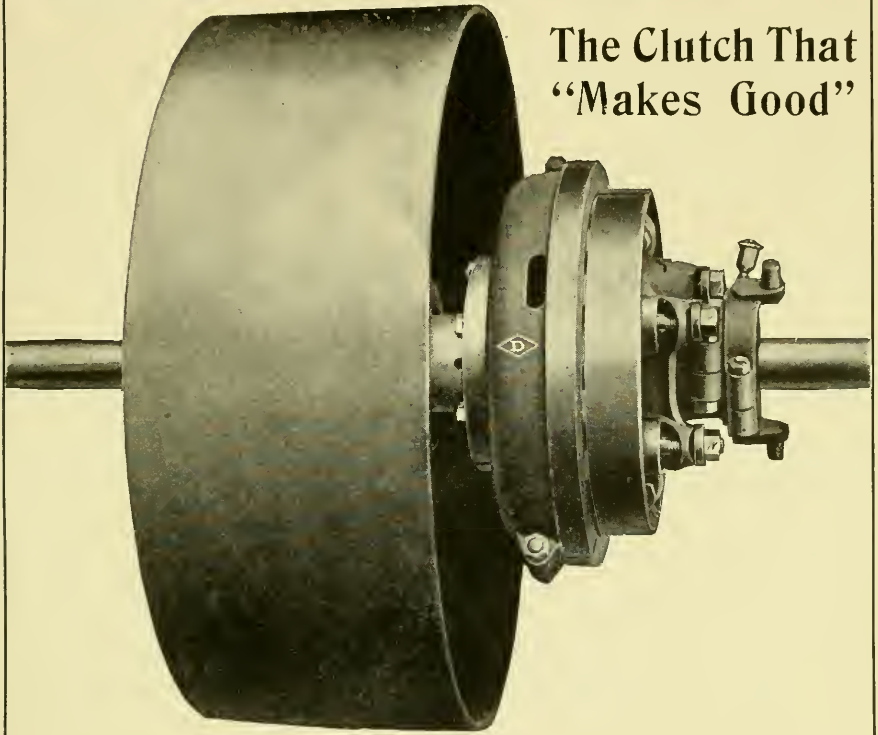
The Clutch That "Makes Good"



A CEMENT mill in Ohio that two years ago had no end of trouble with friction clutches, ordered a Dodge Split Clutch to replace one of them. It "made good" and six more Dodge Clutches replaced the troublesome ones.

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Archiv fur Eisenbahnwesen. To Jan. 1908.
Association Railway Superintendents of Bridges and Buildings. *Proceedings.* Vol. 1–14. 1892–1905. Vol. 17. 1907.
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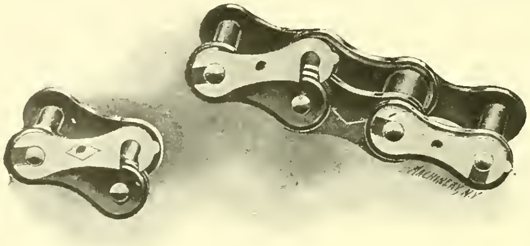
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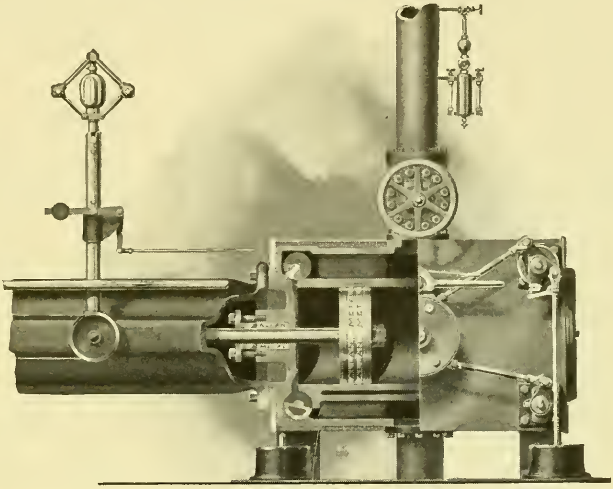

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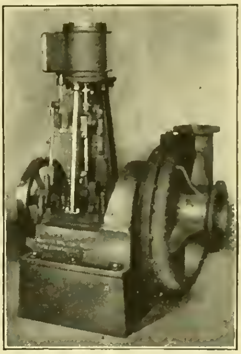

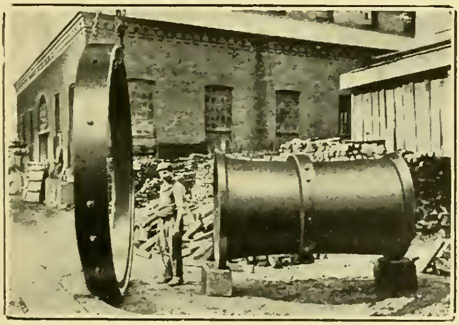

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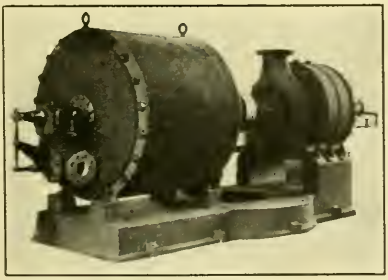

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ALPHABETICAL LIST OF ADVERTISERS

	Page
Albany Steam Trap Co	17
Allan & Son, A	27
Alliance Machine Co	20
American Engine Co	14
American Gas Furnace Co	6
American Goetze-Gasket & Packing Co	18
American Swiss File & Tool Co	4
Arnold Co., The	30
Bacon, Earle C	30
Baldwin, Bert. L	30
Buckeye Engine Co	13
Builders Iron Foundry	29
Carpenter Tap & Die Co., J. M	5
Carrier Air Conditioning Co	27
Chisholm & Moore Mfg. Co	22
Clarkson School of Technology	30
Cleveland Crane & Engineering Co	20
Conard, William R	30
Dean, F. W	30
Detroit Lubricator Co	17
Detroit Stoker & Foundry Co	15
Diamond Chain & Mfg. Co	26
Dixon Crucible Co., Joseph	18
Dodge Co., J. M	18
Dodge Mfg. Co	23
DuBois Iron Works	15
Electric Controller & Mfg. Co	19
Engineering Schools and Colleges	30
Errington, F. A	4
General Electric Co	8
Golden-Anderson Valve Specialty Co	18
Heine Safety Boiler Co	15
Hooven, Owens, Rentschler Co	14
Hurley & Co., D	30
Jeanesville Iron Works Co	29
Jeffrey Mfg. Co	21
Jones & Lamson Machine Co	2–3
Kennedy Valve Mfg. Co	17
Kerr Turbine Co	29
Lindstrom, John T	17
Link-Belt Co	21
Link Chain Belt Co	20
Main, Chas. T	30
Manning, Maxwell & Moore	7
Mason Regulator Co	9
Morris Machine Works	29
Morse Twist Drill & Machine Co	7
Murray Iron Works Co	13
National Machinery Co	7
National Meter Co	12
Nelson Valve Co	11
Newark Gear Cutting Machine Co	6
New York University School of Applied Science	30
O'Neill, J. G	30
Polytechnic Institute of Brooklyn	30
Pratt & Whitney Co	1
Professional Cards	30
Reichhelm & Co., E. P	4
Rensselaer Polytechnic Institute	30
Ridgway Dynamo & Engine Co	10
Riverside Engine Co	14
Robb-Mumford Boiler Co	12
Roebling's Sons Co., John A	26
Russell, Burdsall & Ward Bolt and Nut Co	6
Seneca Falls Mfg. Co	5
St. Louis Iron & Machine Works	15
Simmons Co., John	9
Standard Tool Co	7
Struthers-Wells Co	10
Tufts College	30
University of Michigan	30
Walch & Wyeth	16
Warner & Swasey Co	1
Washburn Shops	6
Wheeler Mfg. Co., C. H	14
Whiting Foundry Equipment Co	20
Whiton Machine Co., D. E	4
Wisconsin Engine Co	9
Yale & Towne Mfg. Co	19

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THE JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

SEPTEMBER 1909

NEXT MONTHLY MEETING, OCTOBER 12
ANNUAL MEETING, NEW YORK, DECEMBER 7-10

Edwin Reynolds

PAST PRESIDENT
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SEPTEMBER 1909 VOL. 81 No. 7

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLISHED AT 2427 YORK ROAD - - - - BALTIMORE, MD.
EDITORIAL ROOMS, 29 W. 39TH STREET - - - - NEW YORK

CONTENTS

FRONTISPIECE, Edwin Reynolds.
SOCIETY AFFAIRS 3
Meetings of the Society (3), Hudson-Fulton Celebration (3), Meeting of the Council (4), Sections and Branches: Gas Power Section (6), Stevens Engineering Society (7), St. Louis and Boston Meetings (8); General Notes: Lehigh University (13), Sorbonne Medal (13), Contribution to Congressional Record (13), Dinner to Professor Breckenridge (13), Portrait of Charles B. Richards (14), Conservation Congress (14), Avery Engine (15), Russell Sage Laboratory (15), President MacLaurin (16), International Association for Testing Materials (17); Other Societies: American Institute of Electrical Engineers (18), American Society of Civil Engineers (18), American Institute of Chemical Engineers (18), Society of Naval Engineers and Architects (19), Society for the Promotion of an Engineering Education (19), National Association of German-American Technologists (19); Necrology: Edwin Reynolds (20), A. J. Caldwell (21), Alexander Miller (22), D. H. Gildersleeve (22), A. W. K. Peirce (23), Jang Landsing (24); Personals (25).
SOCIETY HISTORY 835

PAPER

High-Pressure Fire Service Pumps of Manhattan Borough, R. C. Carpenter 839

DISCUSSION

Small Steam Turbines, Geo. A. Orrok, Washington meeting. C. B. Rearick, W. D. Forbes, R. H. Rice, R. C. Carpenter, H. Y. Haden, F. D. Herbert, W. E. Snyder, W. T. Donnelly, F. H. Ball, C. A. Howard, Boston meeting; L. C. Loewenstein, W. J. A. London, C. G. Rearick, F. B. Dowst, C. B. Edwards, V. F. Holmes, J. S. Schumaker, C. A. Read, I. N. Hollis, E. F. Miller, J. T. Hawkins, R. H. Rice, C. H. Manning, C. P. Crissey, C. B. Burleigh, J. H. Libbey, the Author 865

THE JOURNAL is published by The American Society of Mechanical Engineers twelve times a year, monthly except in July and August, semi-monthly in October and November.
Price, one dollar per copy—fifty cents per copy to members. Yearly subscription, $7.50; to members, $5.
Application filed for entry at the Postoffice, Baltimore, Md. as second-class mail matter under the act of March 3, 1879

GAS POWER SECTION

Report on Gas Producer Development Abroad, C. L. Straub........ 896
DISCUSSION
Marine Producer Gas Power, C. L. Straub. Geo. Dinkel, I. E. Moultrop, H. M. Wilson, E. T. Adams, the Author........ 901
Operation of a Small Producer-Gas Power Plant, C. W. Obert. J. A. Holmes, J. H. Morris, W. A. Bole.................. 907
A Method of Improving the Efficiency of Gas Engines, T. E. Butterfield. A. M. Green, Jr., W. C. Barnes, the Author... 910
Offsetting Cylinders in Single-Acting Engines, T. M. Phetteplace. W. H. Herschel, J. H. Norris, the Author.. 916
NEW BOOKS.. 922
ACCESSIONS TO THE LIBRARY.................................... 925
EMPLOYMENT BULLETIN.. 931
CHANGES IN MEMBERSHIP.. 934
COMING MEETINGS.. 943
OFFICERS AND COMMITTEES...................................... 946

The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 31 SEPTEMBER 1909 NUMBER 7

MONTHLY meetings of the Society are to be held in New York on the evenings of October 12 and November 9. The Annual New York Meeting will be held December 7–10. The importance and interesting character of papers on hand and in preparation assure professional sessions for these meetings of the greatest possible value to the membership and indicate an even larger attendance than in preceding years. As announced elsewhere in this number in the reports of the meetings of the Society held early in the summer in Boston and St. Louis, arrangements are well advanced for meetings in these cities throughout the fall and winter. The subjects for several of the Boston meetings have already been tentatively announced in the report referred to and papers are promised which should add materially to the value of the publications of the Society.

HUDSON-FULTON CELEBRATION

In connection with the Hudson-Fulton Celebration in September and October, in New York, and as a contribution on the part of the engineering profession, there will be placed in the rooms of The American Society of Mechanical Engineers, on the eleventh floor of the Engineering Building, a valuable exhibit of objects of interest relating to the early history of steam navigation. This exhibit is being prepared by a sub-committee of the House Committee of the Society, in accordance with action of the Executive Committee of the Council, taken in response to an invitation received January

7, from the Historical Exhibit Committee of the Hudson-Fulton Celebration Commission.

A room of the Society will be set apart early in September for the exhibit. It will be open to the public every week-day from nine to five.

The exhibit will include the following material belonging to the Society: oil portrait of Robert Fulton by himself; original drawing of the Clermont by Robert Fulton and signed by him March 1, 1813; solid mahogany table formerly belonging to Robert Fulton; autograph brush drawing by Robert Fulton, 1797, illustrating an aqueduct for a high level canal; reproduction in bronze of the Fulton drawing of the Steamer Potomac, 1820, prepared by the Society; letters of Fulton's workmen concerning the first steamboat; photograph of West portrait of Fulton; portraits of naval and marine engineers, as Haswell, Loring, Thurston, Melville, See, Worthington, Ericsson, Watt, Holley, Stillman, etc.

The Society has secured for the exhibit from the United Engineering Society, the Ericsson models; and from the Smithsonian Institution, the models of Fulton's Clermont, John Fitch's steamboat, and John Stevens' Phoenix.

Any members having models or relics of interest in connection with the celebration are requested to communicate with E. Van Winkle, Chairman of the sub-committee, 90 West St., New York.

The special committee on Hudson-Fulton Celebration is as follows: Rear-Admiral George W. Melville, Ret., Past-President, Am.Soc.M.E.; M. L. Holman, Past-President, Am.Soc.M.E.; Jesse M. Smith, President, Am.Soc.M.E.

MEETING OF THE COUNCIL

At the meeting of the council June 2, 1909, there were present: Jesse M. Smith, President, presiding, and Messrs. Bond, Carpenter, Miller, Riker, Swasey, Stott, Oberlin Smith, Whyte, A. M. Waitt and the Secretary. Letters of regret were received from Messrs. Humphreys and Moultrop.

Announcement was made of the deaths of A. J. Caldwell, Manager, A. W. K. Peirce, and Alex. Miller. The resignation of Charles W. Kettell was accepted.

Voted: To approve the following appointments by the President of Honorary Vice-Presidents: Jesse M. Smith to represent the Society at the Commencement exercises of Columbia University; Calvin W.

Rice and Worcester R. Warner to represent the Society at the Inauguration of Richard Cockburn MacLaurin as President of Massachusetts Institute of Technology.

Voted: To authorize the Finance Committee at its discretion to appropriate $300 for the work of the Committee on Power Tests.

Voted: To refer to the Committee on History the communications received from John E. Sweet and Ambrose Swasey with respect to organization members of the Society.

Voted: That a committee of three be appointed by the President to consider the communications from the Association of Steel Manufacturers, under dates of January 13 and February 2, and report to the Council.

Voted: To approve the recommendation of the Executive Committee with respect to the appointment of Dr. Charles B. Dudley, as Honorary Vice-President, to represent the Society at the Congress of the International Association for Testing Materials, to be held in Copenhagen, Sweden, September 7 to 11, 1909.

Voted: To approve the action of the Meetings Committee, declining the petition for a National Conference on the subject of Smoke Abatement.

Voted: That the Council suggest to the Meetings Committee that it may arrange for a monthly meeting in the near future on the subject of Smoke Abatement on strictly engineering lines.

Voted: That the Executive Committee be given entire charge of the arrangements for a joint meeting of the Society with the Institution of Mechanical Engineers in England, during 1910, at such time and place as may be selected by the Institution.

Amendments: Upon the recommendation of the Committee on Constitution and By-Laws, the following amendments were adopted:

B 17 A ballot which contains more unerased names than there are officers to be elected is thereby defective and shall be rejected by the tellers.

R 30 The American Society of Mechanical Engineers will furnish monthly issues of The Journal to all members of affiliated organizations who are not members of The American Society of Mecanical Engineers upon the payment by each of two dollars per year. The American Society of Mechanical Engineers will also furnish to the secretary of each affiliated body, a certain number of extra copies of advance papers for use at its meetings, the number furnished to be agreed upon in each case.

R 4 Each paper which has been accepted by the Committee on Meetings for presentation at any meeting of the Society shall be published in The Journal at least seven days in advance of that meeting and in the form in which has been accepted by that committee, and that paper shall also be distributed in pamphlet form at that meeting. A paper received too late for such distribution shall only be accepted for presentation at that meeting by unanimous consent of the Committee on Meetings. A member may by letter signify his intention to discuss any of the papers and unless otherwise directed by the presiding officer priority in debate shall be given in the order of the receipt by the Secretary of such notification.

Voted: To add to the Rules the following and refer back to the committee for consideration under C 47:

R 2 The Council shall, previous to January first of each year, elect a Trustee to serve for three years on the Board of Trustees of United Engineering Society.

Voted: To rescind the action of the Council of January 31, 1905 authorizing rules for the organization and conduct of geographical sections, given in Transactions of the Society, Vol. 27, pages 39 and 40.

It was further voted to approve the recommendations of the Committee regarding C 10 and C 11.

On motion the meeting adjourned.

SECTIONS AND BRANCHES

WORK OF THE GAS-POWER SECTION

During the summer the work of the Gas-Power Section has been actively carried on. The Installations Committee has collected data for presentation at one of the meetings of the section. The Plant Operations Committee has several installations under observation from which information is being obtained.

The Membership Committee reports that the membership of the section is above 330 and many of the applicants for membership in the section have also applied for membership in the Society.

The work in the smaller cities throughout the United States is thoroughly organized and the results of these efforts are becoming apparent. The committee is gratified at the many requests received for information. The Literature Committee has reviews and indexes of articles and publications in preparation, which will soon be available to those seeking information.

At the meeting of the Gas Power Executive Committee early in July, in accordance with a request from several colleges, an Advisory Research Committee was appointed to assist the Executive Committee in preparing a plan of work which should avoid as far as possible unnecessary duplications and produce the best results in the solution of the various problems now open. This committee includes the following: R. H. Fernald, C. P. Breckenridge, R. C. Carpenter, W. T. Magruder, W. D. Ennis, C. E. Lucke, L. S. Marks, H. N. Davis, D. L. Gallup, W. H. Kavanaugh.

A list of important problems, the solution of which is greatly needed, is being prepared and it is expected that the results obtained by the help of this list will be of great value. The Meetings Committee has been promised four valuable papers for the coming season and several others are in prospect for later delivery.

ACTIVITIES OF THE BROOKLYN POLYTECHNIC STUDENT SECTION

The Student Section of the Society at the Brooklyn Polytechnic Institute held a meeting on May 1, which was addressed by Prof. Wm. D. Ennis, Mem.Am.Soc.M.E., professor of mechanical engineering of the Institute. The subject of his address was The Manufacture of Vegetable Oils. At the meeting of June 5, James A. Nelson delivered an illustrated lecture on Hydraulic Machinery. The program committee reported that meetings of similar value are outlined for the coming year.

LECTURES BEFORE THE STEVENS ENGINEERING SOCIETY

The Stevens Engineering Society, affiliated with The American Society of Mechanical Engineers, has arranged for a number of lectures during the coming college year at Stevens Institute of Technology. As will be seen from the following list, the speakers are men high in their profession and the topics cover a wide range: F. A. Waldron, Mem.Am.Soc.M.E., "The Commercial Value of a Specialist;" Fred. W. Taylor, Mem.Am.Soc.M.E., "Success;" Prof. F. R. Hutton, Hon. Secy., Am.Soc.M.E., "The Problems of the Large Gas Engines;" Prof. H. C. Sadler, on some branch of naval architecture; Prof. D. C. Jackson, Mem.Am.Soc.M.E., "Engineering Education;" Chas. W. Baker, Mem.Am.Soc.M.E., "The Panama Canal;" H. G. Stott, Mem.Am.Soc.M.E., subject to be announced; Rear Admiral Melville, Mem.Am.Soc.M.E., "The Essentials of Naval Efficiency in an Age of Engineering;" C. de Zafra, "Explosives;" Hudson Maxim, "The Warfare of the Future;" T. C. Martin, subject to be announced; Samuel Whinery, Mem.Am.Soc.M.E., "Street Pavements and Road Construction;" H. L. Gantt, Mem.Am.Soc.M.E., "Industrial Management;" Professors G. V. Wendell and L. A. Martin, "The Gyroscope;" Frank B. Gilbreth, Mem.Am.Soc.M.E., "Methods and System in Relation to Handling Concrete Work;" Prof. J. C. Ostrup, "Notable Examples in Modern Construction;" Naval Constructor D. W. Taylor, "The Development of the New Navy;" Prof. C. F. Kroeh, subject to be announced; J. A. Brashear, Hon.Mem.Am.Soc. M.E., "The Contributions of Photography to Our Knowledge of the Stellar Universe."

MEETINGS IN BOSTON AND ST. LOUIS

MEETING OF THE SOCIETY AT ST. LOUIS

A meeting was held at the Missouri Athletic Club, St. Louis, Mo., on May 15 to discuss the question of holding meetings of the Society. William H. Bryan, member of the Meetings Committee, presided, Prof. E. L. Ohle acting as secretary.

The report of the committee on organization was first presented, the committee recommending that the Society coöperate with the Engineers' Club of St. Louis in the matter of meetings and publications.

In opening the discussion, M. L. Holman, Past President Am. Soc.M.E., said that the question of enlarging the sphere of usefulness of national engineering societies without interfering with local organizations, many of which antedate the national organizations, is one which has been given much thought by the engineers of the country. The St. Louis Engineers' Club is an earlier organization than The American Society of Mechanical Engineers. It has taken some years to bring it up to its present standing; it has a good record and a strong organization. The engineers of St. Louis could not afford to take any steps that would interfere in any way with the usefulness of the club or in any way impede its growth and importance.

The movement under consideration, however, was not to antagonize local engineering clubs, but was intended to help them in every way practicable. The movement was for the purpose of bringing more engineers into the societies, both local and national, and any work that could be done to accomplish this result would be for the benefit of both the local and the national organization. The members of the Society had started the movement in Boston and were working in sympathy with the Boston Society of Civil Engineers. He could only express his approval of the work done in St. Louis in harmony with the Engineers' Club of that city. In conclusion, Mr. Holman moved the adoption of the report.

R. H. Tait expressed himself as heartily in accord with the monthly meetings in St. Louis. Wm. H. Bixby felt that the Society as a national society should have local meetings in different cities, but the difficulty would be to make these national in character, with the papers fully and freely discussed.

In answer to a question by Prof. H. Wade Hibbard as to the attitude of the members of the Engineers' Club toward the coöperative movement, Wm. H. Byran said that four ex-presidents of the club had obtained the views of club members and as far as could be learned they were in favor of the movement. He could imagine no grounds for objection. All responsibility and, at present, all expenses were assumed by the Society. The Society proposed to join in the responsibility of maintaining the mechanical engineering division of the club's work, which, to the speaker, seemed a proposition that the club would readily accept. Mr. Bryan said further that the plan for organization would be submitted to the New York office of the Society for approval and, granting favorable action, would then be submitted to the Engineers' Club.

With regard to the question of a meeting night Mr. Bryan thought it might be the night following the meeting of the St. Louis Railway Club, held on the second Friday of each month. If a local meeting of the Society were held on the Saturday evening following, a number of mechanical engineers and master mechanics would stay over Friday and attend the meeting. It was not proposed to take one of the two regular meeting nights of the Engineers' Club, though this might be done occasionally.

There was no question, said Thomas Appleton,that the holding of local meetings would be to the advantage of each local member as well as to the national Society. The movement had been started in the right way.

Professor Westcott, though not a member, pledged his support for the meetings. The success of the movement would mean much to those outside of St. Louis, as it would afford them an opportunity to meet the leading engineers of that vicinity.

The holding of local meetings, said F. L. Jefferies, would in no way interfere with the growth or strength of city clubs, as members of the Society would become better acquainted with engineers of that section and would be more likely to join city clubs. Neither would there be any likelihood of the members resigning from the Society to join local clubs, as the Society membership would be of value to them whether they remained in that city or went elsewhere.

W. M. Armstrong expressed some doubt as to the possibility of obtaining papers of national interest at each meeting. He thought that the discussions might prove of local interest only.

While the difficulty of obtaining monthly papers up to the full Society standard was realized, said Mr. Bryan, the discussions could be much less formal in character, the Society exercising its judgment as to what part, if any, would be published.

The question of publication, Mr. Holman pointed out, was fully settled by issuing the monthly Journal and the yearly Transactions. Papers on subjects that are developing, and those that, while interesting and instructive, are not monumental, are published in The Journal with the other proceedings of the Society. Papers of high quality pass through The Journal as a sieve and are then published in the Transactions. A report of any meeting would appear in The Journal, but only contributions to permanent literature would be accepted for the Transactions.

Both Mr. Bryan and Professor Hibbard spoke on the desirability of not anticipating difficulties but of solving each problem as it was presented. The latter speaker was hopeful for the development of the talent among mechanical engineers which the proposed meetings would bring about. He felt that in approaching the questions which would come up they should proceed as well as possible, inspired with the knowledge that their growth would produce papers and discussions of value to the profession throughout the country.

J. A. Laird expressed his approval of the report of the committee. The scheme outlined would be in no way a detriment to the Engineers' Club of St. Louis. He would be opposed to any local organization that would detract from the Engineers' Club, but he believed that the proposed plan would help the club by creating an interest in mechanical engineering papers and the discussion on them. The presentation of papers in connection with the club meetings he believed would add to the interest of the meetings and increase the club's membership.

Victor Hugo thought that St. Louis should be represented in the Society in the manner proposed, and local engineers should avail themselves of the opportunity for initiating the movement.

E. A. Fessenden, speaking as one of the younger members, said that while he considered The Journal and the Transactions valuable, the associations which Society membership made possible were more so. The St. Louis meetings would enable the younger members to come into personal touch with older and more experienced engineers and would convert into live, active members those who felt that membership in the Society was largely nominal.

Following Mr. Fessenden, the adoption of the report was then considered, the vote being unanimously in its favor. A motion to continue Mr. Bryan as chairman and Professor Ohle as secretary was also adopted. The thanks of the meeting were also voted to the chairman and to those assisting him in the work of organizing.

The chairman then called on Prof. F. H. Vose, the only local member of the Society who had attended the Washington convention, to make a brief report of the proceedings at the convention.

While it was his first experience at a meeting of the national Society, Professor Vose said he was distinctly impressed with the fact that the Society was by no means a New York organization. He met men from all over the country and they seemed to have their share in the management of affairs. He did not believe that they were trying to fix the character of the local meetings at St. Louis but rather that they earnestly desired to place these meetings on the same footing as those held monthly in New York.

Professor Vose then gave an interesting running account of the papers and discussion presented at Washington.

BOSTON MEETING, JUNE 11

Following the plan of holding meetings of the Society in cities other than New York, inaugurated at the meeting of the Society in Boston on April 16, details of which were given in the June issue of The Journal, a meeting was held there on June 11, at which Geo. A. Orrok's paper on "Small Steam Turbines" was presented for discussion.

Prof. Ira N. Hollis, who presided, first outlined the work proposed for the meetings of the Society in Boston saying that the committee was planning a number of meetings after October 1 and was endeavoring to obtain papers in season for publication in The Journal. In order to show what preparation had been made Professor Hollis read the following list of subjects, papers on which had been promised or which it was hoped to obtain:

"A Comparison of the Different Methods of Figuring the Strength and Stiffness of Reinforced-Concrete Beams."

"Cooling Towers and Spraying Nozzles for Cooling Towers."

"The Action of Superheated Steam on Different Metals."

"Friction Loss in Turbine Nozzles."

"The Effect of Bleeding Steam from Turbines for Manufacturing Purposes."

"Air Pumps and Condensers."

It was also desired to obtain a list of all engineers interested in the meetings. Notices had been sent to 950 engineers in the vicinity of Boston. Of that number 340 were members of the Society, so that a substantial number were available as a neucleus. Professor Hollis then called on Secretary Calvin W. Rice to address the meeting.

The meeting, said Mr. Rice, was in every sense a meeting of the Society, just as though it were held in New York. He had been asked by the editor of a technical paper if it were allowable to publish the proceedings of the meeting and had replied that the Society desired that the widest publicity be given to all the proceedings. He had great appreciation for the work of the committee in making the meetings possible and further he emphasized that the present meeting was an official one and the members had the right to expect the presence and assistance of the officers of the Society.

Mr. Rice expressed pleasure at the possibility of a joint meeting with the Boston Society of Civil Engineers as it was the desire of The American Society of Mechanical Engineers to unify and bring together all engineers and not to establish additional societies.

Professor Hollis then asked Prof. E. F. Miller to read Mr. Orrok's paper, after which the meeting was given over to discussion.

GENERAL NOTES

GIFT TO LEHIGH UNIVERSITY

John Fritz, Past-President and Hon.Mem.Am.Soc.M.E., has given $50,000 to Lehigh University for an engineering laboratory. Mr. Fritz has been a trustee of the university for over thirty years. The Board of Trustees has appropriately recognized this gift [by naming it the John Fritz Engineering Laboratory.

SORBONNE MEDAL PRESENTED TO ANDREW CARNEGIE

A medal was presented to Andrew Carnegie, Hon.Mem.Am.Soc. M.E., by the Council of the Sorbonne, Paris, on May 26, in recognition of his founding of the Curie scholarship in 1906. The guests of the occasion, in addition to the entire faculty of the college, were Madame Curie, Ambassador White, Baron D'Estournelles de Constant and M. Niet, President of the French Salon.

CONTRIBUTION TO THE CONGRESSIONAL RECORD

The article on The Lock Canal at Panama contributed to the May number of the Outlook by John R. Freeman, Past-President Am. Soc.M.E., and member of the special board appointed to investigate the Gatun Dam, together with an editorial article by Charles Whiting Baker, Mem.Am.Soc.M.E., and Editor of the Engineering News, was presented before the House by Hon. Wm. H. Wiley, Treasurer, Am.Soc.M.E., and was ordered published in the records of that body.

UNIVERSITY OF ILLINOIS DINNER TO PROFESSOR BRECKENRIDGE

Prof. L. P. Breckenridge, who recently resigned from the department of mechanical engineering of the University of Illinois, to take up his work as director of the same department of the Sheffield Scientific School at Yale University, was tendered a farewell dinner on the evening of June 21, by the engineering alumni of the university from Chicago and vicinity. Professor Breckenridge spoke of his new work and also of the keen interest which he would always have in his former connections.

PORTRAIT OF PROF. CHARLES B. RICHARDS

The portrait of Prof. Charles B. Richards, Mem.Am.Soc.M.E., was recently painted by Emil Fuchs, for presentation to Sheffield Scientific School of Yale University by a committee composed of Professor Richards' former pupils. Professor Richards, who was one of the organization members of The American Society of Mechanical Engineers, is retiring from his position as head of the department of mechanical engineering of Sheffield Scientific School after a quarter of a century of continuous service.

FIRST NATIONAL CONSERVATION CONGRESS

The First National Conservation Congress of the United States of America, composed of representatives from each of the important industries and callings throughout the country, convened August 26–28 in the auditorium of the Alaska-Yukon-Pacific Exposition at Seattle, Wash. This is the first general convention covering the conservation and utilization of all related and interdependent resources of the nation, although there have been important general meetings devoted to one or two special branches of this movement. The Congress was held under the auspices of the Washington Conservation Association, with the approval of conservation commissions and committees of states and of the joint committee on conservation between states and nations, and had among its speakers men of international eminence. Members appointed to represent the Society at the Congress were: Robert M. Dyer, Myron Knox Rogers, Wm. F. Zimmermann.

AVERY ENGINE PRESENTED TO THE SOCIETY

Prof. John E. Sweet, Past-President and Hon.Mem.Am.Soc. M.E., and a nephew of William Avery, the inventor, has presented to the Society the rotor of one of the original engines built in Mr. Avery's shop in Syracuse, N. Y., sometime between 1835 and 1840. The Avery engine was a rotary engine, or turbine of the reaction type, having a hollow forged rotor in the form of two diametrically opposite arms. The arms were hung on a hollow shaft through which the steam entered, passing through the hollow arms and escaping through orifices at their ends.

In a description of the engine Prof. Sweet states that the shaft had no metal bearings except at the extreme outer end and beyond the driving pulley; at the end of the shaft opposite the steam pipe, where the steam entered the hollow shaft, rollers were placed to take the pressure of the steam, usually 150 lb. The metal bearing referred to was in connection with these rollers. On each side of the case in which the arms revolved was a packing box in which hemp packing was used. These two packing boxes made the main bearings of the engine.

A Mr. Herrick, who helped build and operate the engines, said that when slide-valve engines were substituted for Avery engines no gain was made in steam economy. Trouble was had with the packing and with the cutting out of the blades at the ends of the arms. Mr. Avery refers in his notebook to a rotor 7 ft. long which ran 14¼ miles a minute.

DEDICATION OF RUSSELL SAGE LABORATORY AT RENSSELAER POLYTECHNIC INSTITUTE

The new building for the School of Mechanical and Electrical Engineering, erected through the generosity of Mrs. Russell Sage, was formally opened on June 15, in the presence of a large gathering of alumni and well-known engineers. Addresses were made bv Robert W. DeForest, of New York, Mrs. Sage's attorney and representative, by Jesse M. Smith, Pres.Am.Soc.M.E., and an alumnus, and by Lewis B. Stilwell, Pres.Am.Inst.E.E.

President Smith said in part: Rensselaer Polytechnic Institute has a higher destiny than the education of men in a single branch of engineering, and in this eighty-fifth year of its growth mechanical engineering has finally been recognized. No engineering work of importance can progress far without it and engineering has taken such an important part in the activities of this country that no industry can attain prominence unless it be entrusted principally to engineers. An engineer who does not look beyond his own circumscribed horizon cannot become great, for the fields covered by the various branches of his profession overlap one another and new conditions constantly arise so that he cannot tell what he will be called upon to do next. The establishment of courses of mechanical and electrical engineering in addition to civil engineering simply means that the trustees and faculty of Rensselaer have recognized the demand for a higher and broader education. It is possible that in the future each graduate of an engineering school will receive the same general degree and that after years of practice he may return to the Institute and be examined for a degree in his chosen specialty. I hold for the highest possible school education for the engineer without regard to specialty.

The Institute now possesses three splendidly equipped new buildings erected within the last four years. Of the Sage gift of $1,000,000. the sum of $700,000 has been reserved for a permanent endowment fund.

The Society was further represented at the dedication by Charles Whiting Bakeı, Editor of Engineering News, Profs. Wm. H. Burr and Fredk. A. Goetze of Columbia University, Prof. H. W. Spangler of the University of Pennsylvania, and Wm. B. Cogswell, of Syracuse.

INAUGURATION OF PRESIDENT MACLAURIN

Richard Cockburn MacLaurin, formerly associated in educational work in England and Australia and later professor of mathematical physics at Columbia University, was inaugurated President of the Massachusetts Institute of Technology on June 7. On the platform were representatives of almost every department of educational and scientific activity, including college presidents from all parts of the United States and members of scientific associations and technological institutions. In accordance with a vote of the Council, the Society was represented by Worcester R. Warner, Past-President and Calvin W. Rice, Secretary and graduate of the Institute.

Among the speakers were Frederick P. Fish, a member of the executive committee of the corporation, who announced the election of Professor MacLaurin as president of the Institute; Governor Eben S. Draper of Massachusetts, a graduate of Massachusetts Institute of Technology; ex-president Pritchett, now president of the Carnegie Foundation for the Advancement of Teaching; James P. Munroe, former president of the Alumni Association of the Institute; President A. Lawrence Lowell of Harvard University; The Right Honorable James Bryce, ambassador from Great Britain; and Dr. Arthur A. Noyes, chairman of the faculty.

In his inaugural address, President MacLaurin outlined his creed as an educator. He said in part: The end of education is to fit men to deal honestly, intelligently and efficiently with the affairs of a life as abundant and complete as possible. Science should play a very prominent if not a leading part in the higher education of an increasing section of the community, since the great problems of a nation today are mainly scientific, and the quickness with which the different nations have grasped the fact that energy, courage and doggedness are no longer enough to win the fight, might be used as a touchstone of their intelligence. Science and culture must be combined. The root of culture is the possession of an ideal broad enough to form the basis of a sane criticism of life, and technical schools should not only train men for those professions in which science plays a leading part but should in addition fit them to extend the bounds of knowledge in as many directions as they see opportunity. Above all, the freshness and vigor of youth must be preserved in our students and their natural powers of initiative improved outside the classroom by a rational system of athletics and a rational social life.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS

Dr. Charles B. Dudley, Mem.Am.Soc.M.E., has been appointed delegate on the part of the United States to the Congress of the International Association for Testing Materials to be held at Copenhagen, September 7–11, 1909. Dr. Dudley will also act as official delegate of this Society to the Congress.

OTHER SOCIETIES

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The twenty-sixth annual convention of the American Institute of Electrical Engineers was held at Frontenac, N. Y., June 28–July 1. The registration reached a total of 286.

Among the papers presented were: Alternator for 100,000 Cycles, Multispeed Induction Motors, Alternating-Current Motors versus Direct-Current Motors in Steel Mills, Power Requirements for Rolling High-Carbon Steel of Small Section, Electrical Control for Rolling-Mill Motors, The Training of Non-Technical Men.

The Society was represented at the convention by J. W. Lieb, Jr., S. Hosmer, Paul M. Lincoln, Prof. Morgan Brooks, D. B. Rushmore, W. G. Carleton, C. W. Stone, Earl Wheeler, W. N. Ryerson, H. G. Reist, A. H. Kruesi, W. I. Slichter, and others.

AMERICAN SOCIETY OF CIVIL ENGINEERS

The annual convention of the American Society of Civil Engineers was held July 6–9, at Mt. Washington Hotel, Bretton Woods, N. H. The presidential address was delivered at the opening session by Onward Bates, on The Status of the Civil Engineer's Profession in the United States. Two reports were discussed, one on the Status of the Metric System, the other that of the Special Committee on Concrete and Reinforced Concrete. Among the papers presented were: Fire Resistant Construction in Buildings, by Herbert M. Wilson; Impurities in Sand for Concrete, by S. E. Thompson; and Road Watering as Compared with Oiling for Laying Dust, by Saml. Whinery, Mem.Am.Soc.M.E.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

A new national society, the American Institute of Chemical Engineers, held its first meeting in the Brooklyn Polytechnic Institute, New York, June 24–26. During the first day papers were presented on the following subjects: The Limits of Efficiency of the Power Gas Producer, Prof. W. D. Ennis, Mem.Am.Soc.M.E.; The Utilization of Low-Grade Fuels in the United States, O. K. Zwingenberger;

Creosote Oil from Water Gas Tar, S. P. Sadtler; The Centering of Great Industries in the Metropolitan District, Dr. C. F. McKenna; Experiments in the Case-Hardening of Steel with Gases, Prof. J. C. Olsen; Methods of Clay Control, J. G. Dean. The remaining days of the convention were spent in trips to plants of interest, such as the Atlantic Lead Works in Brooklyn and the Standard Oil Company's works in Bayonne, N. J.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

The summer meeting of the Society of Naval Architects and Marine Engineers was held at Detroit, Mich., June 24–26. Papers were presented on Some Model Experiments on Suction of Vessels; A Method of Determining Pressures in Steam Turbines; The Resistance of Some Full Types of Vessels; The U. S. S. Michigan, renamed the Wolverine; Shallow Draft-Steamers; Material Handling Arrangement for Vessels on the Great Lakes; The Strength of Knees and Brackets on Beams and Stiffeners; and Towing Problems. The Society was represented at the meeting by T. H. Hinchman, Jr., Alex Dow, W. J. Keep and Walter S. Russel, of Detroit, and Prof. M. E. Cooley, of Ann Arbor, Mich.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

The Society for the Promotion of Engineering Education held its annual convention in New York, June 24–26, meeting for its several sessions in the Engineering Societies Building, at Columbia University and at Pratt Institute. Papers were presented by Prof. F. E. Turneaure on Present Tendencies in Technical Education; by Charles Buxton Going on The Relation of Engineering Education to Industry; by Fred. W. Taylor, Mem.Am.Soc.M.E., on The Preparation of Technical Graduates for Industries; and by Prof. Hugo Diemer, Mem.Am.Soc.M.E., on Employers' Requisites of Technical Graduates.

NATIONAL ASSOCIATION OF GERMAN-AMERICAN TECHNOLOGISTS

The silver anniversary of the founding of the National Association of German-American Technologists was celebrated in Philadelphia, Pa., August 28–31. In addition to the sessions of delegates, trips were made to various points of engineering importance in and about the city. G. A. Stierling delivered a lecture before the association on Reinforced Concrete.

NECROLOGY

EDWIN REYNOLDS

Past-President, Am.Soc.M.E.

Edwin Reynolds was born in Mansfield, Conn., March 23, 1831, and was apprenticed at the age of 16 to A. P. Kenney, a local machinist. At the end of three years' apprenticeship he started on a journeyman's tour of various shops in lower New England.

About 1857 Mr. Reynolds went West and for a time was superintendent of the shops of Steadman & Co., of Aurora, Ill., builders of engines, sawmill machinery, drainage pumps, etc., for the Southern trade. As this business practically ceased during the Civil War, he returned to the East and was employed in several machine works until, in 1867, having attracted the attention of George H. Corliss, he was offered a position in the works of the Corliss Steam Engine Company, at Providence, R. I., where he remained as general superintendent until 1877. His last notable work with the Corliss company was the design of a rolling-mill engine to run at 160 r.p.m. a speed double that of previous designs. This engine was installed at the works of the Trenton Iron Co., in 1877. In 1890 a second flywheel was added and the speed increased to 180 r.p.m.

In 1877 Mr. Reynolds accepted the position of general superintendent of the Edward P. Allis Company, of Milwaukee, Wis., his first work being to place the company on a paying basis, largely through the development of the Reynolds-Corliss engine. He later developed the building of a varied line of machinery, including large Corliss-engine units for pumping service, mining, air compressing, furnace blast, street-railway work and other purposes. One noteworthy achievement was the building, in 1888, of the first triple-expansion pumping engine for waterworks service. This engine was described by Professor Thurston as "doing continuously so high a duty as to place it among the most remarkable constructions of its class and time, and probably to make its record the highest to date (1894)."

The blowing engine designed by Mr. Reynolds for the original Joliet Steel Company and chosen from among competitive designs submitted by leading engineers in the United States and Europe, embodied a radical departure from accepted practice, but after more than 25 years of continuous experimenting the essential features of this design have not been improved upon.

The well-known story of his sketching the design of the horizontal-vertical four-cylinder compound engine for the Manhattan Railway Company's power house in New York City, while on the train from Milwaukee to New York, illustrates his marvelously quick inventive genius.

At the time of his death, Mr. Reynolds was consulting engineer of the Allis-Chalmers Company, although the illness of the past three years had prevented active duty. He took a great interest to the last in the magnificent new works of the company at West Allis, which had been laid out on a strictly engineering basis, after his plans, at the time the Edward P. Allis Company became merged in the new organization.

He was also interested in a number of other plants of Milwaukee and vicinity, had been the first president of the National Metal Trades Association, and bore the degree of LL.D., conferred upon him by the University of Wisconsin, on the wall of whose college of engineering his name has been carved.

Mr. Reynolds served as Vice-President of the Society from 1892–1894, and as President for the year 1902.

His death occurred at his home in Milwaukee February 19, 1909.

ANDREW JAMES CALDWELL

Andrew James Caldwell, Manager, Am.Soc.M.E., died in New York City, May 10, 1909. Mr. Caldwell was born in Brooklyn, N. Y., May 1, 1858, and was graduated from the University of Maine in 1878, with the degree of B.M.E. He also took a graduate course at Cornell University.

He first entered the employ of the Delamater Iron Works, and later that of one of the regular line steamship companies on the New York and New Orleans route. In 1880 he became connected as draftsman with the firm of Henry R. Worthington, and was closely identified with the designing and development of the Worthington high-duty pumping engine. He was soon made chief of the erecting and testing departments, which dealt with water-works pumping machinery; then assistant to the president, Charles C. Worthington; and finally general manager of the hydraulic works.

Soon after the formation of the International Steam Pump Company, he resigned to take a similar position with the Crane Company of Chicago, by which he was later sent to Bridgeport, Conn., to take charge of the new plant of the Eaton, Cole & Burnham Company, controlled by them. In 1902 he resigned, accepting a position with the National Foundry Association, and later entered the service of the Standard Oil Company, with which he was identified at the time of his death.

Mr. Caldwell was elected Manager of the Society in 1906, and was still serving at the time of his death. He was a member of the Engineers' Club in New York, and one of the organizers and first president of the Brooklyn Engineers' Club.

ALEXANDER MILLER

Alexander Miller, head of the firm of Alexander Miller and Brothers of Jersey City, N. J., died May 6, 1909, at his home in New York. Mr. Miller was born in Aberdeen in 1857 and came to this country at an early age. He began his engineering career at the old Delamater Iron Works of New York, of which his father was superintendent. Later he formed a connection with the Deeley Iron Works and specialized in sugar-evaporating machinery. More recently he applied with conspicuous success the experience thus gained to the problem of the evaporation of brine in the manufacture of salt. Three of the New York fire boats were also the product of his works.

Mr. Miller was a leading factor in the organization of the Delamater Veterans Association, composed of his old associates at the Delamater works, and until the present year was its president. He was also a member of Scotia Lodge, F. & A. M., the Engineers' Club, New York Athletic Club and the St. Andrew's Society.

DAVID HAMILTON GILDERSLEEVE

David Hamilton Gildersleeve was born in Tenafly, N. J., August 5, 1867, and died in New York City, July 30, 1909. He was educated at Stevens Institute of Technology, Hoboken, N. J., and graduated in 1889 with the degree of M.E. For nearly ten years thereafter he was active in gas engineering and the construction and selling of pumps and hydraulic machinery, being associated with the United Gas Improvement Company of Philadelphia, the John H. McGowan Company of Cincinnati, and the Snow Steam Pump Works, New York.

For three years, during and following the Spanish-American War, he served as first lieutenant, United States Corps of Engineers in Cuba, and as assistant engineer of the Department of Havana had charge of the mechanical work executed and planned there. In 1904 he became associated with the C. W. Hunt Company, of West New Brighton, N. Y., as sales manager, which position he resigned in February 1909 to become one of the partners in the shipbuilding firm of the Waters, Gildersleeve, Colver Company, of West New Brighton, Staten Island.

Mr. Gildersleeve became a member of the Society in 1908. He was a member of the Machinery Club, the American Gas Institute, the New York Railroad Club, Dry Dock Association, Staten Island Club, Royal Arcanum, Staten Island Association of Arts and Sciences, Spanish War Veterans Association, the Chi Phi Fraternity, and was Secretary of the Stevens Alumni Association.

A. W. K. PEIRCE

Arthur Warren Kendall Peirce died April 13, 1909, at Driehoek, Transvaal, South Africa, where he had been located since 1897. He was born in West Boylston, Mass., November 19, 1873. His preliminary education was acquired in the Plymouth, Mass., high school, and his technical education by home study and experience in the engineering departments of various electrical companies.

In July 1897, he was appointed electrician to the Knights Deep, Ltd., a gold mining company in the Transvaal, and a year later became consulting electrical engineer to the Consolidated Gold Fields of South Africa, Ltd., a corporation controlling a number of mines in the Transvaal, continuing in this position until 1906. After a trip to England he returned to South Africa in April 1907, to accept an appointment with the Victoria Falls Power Co., Ltd., of Germiston, Transvaal, which he retained to the time of his death.

Mr. Peirce was also a member of the American Institute of Electrical Engineers, the South African Association of Engineers, the Mechanical Engineers' Association of the Witwatersrand, and an associate of the Chemical, Metallurgical and Mining Society of South Africa. He made many extensive trips through the various mining regions of America in search of information regarding hoisting from deep mines, in which work he was professionally interested.

JANG LANDSING

Jang Landsing, whose death occurred July 10, 1909, was born in Heong San, China, October 11, 1864. He was graduated from the Worcester Polytechnic Institute in June 1887, with the degree of B.S.

He was apprenticed to the Washburn Machine Shops for three years, after which he became connected with the Pratt & Whitney Co., as draftsman, leaving after two years to accept a position as machine designer with the Brush Electric Co., of Cleveland.

About 1899 Mr. Landsing, working in cooperation with Mr. Joseph Bijur, assisted in developing a line of special machinery for the manufacture of the "Bijur" type of storage battery. Mr. Landsing became mechanical engineer and then superintendent of the General Storage Battery Co. and was in active charge of the company's large plant at Boonton, N. J., at the time of his death. This work afforded him unusual opportunity to exercise his mechanical ingenuity, and many of the company's successful machines are due to the combination of his fine mechanical judgment and designing skill. He organized and equipped a machine shop for the manufacture of the special tools used by the company and also the 300-kw. power plant. Mr. Landsing had the ability to carry out in an efficient and economical manner work with which he was not previously familiar.

Mr. Landsing was also consulting engineer of the Chinese Legation at Washington.

PERSONALS

Walter C. Allen, Jun.Am.Soc.M.E., formerly General Superintendent of the Yale & Towne Mfg. Co., Stamford, Conn., has been appointed General Manager. with headquarters in New York.

C. Kemble Baldwin, Mem.Am.Soc.M.E., contributed an article, Trailings Disposal Plant at the Wolverine Mill to the July 10 issue of *The Engineering and Mining Journal.*

J. F. Beecher, Assoc.Am.Soc.M.E., has entered the employ of the Pennsylvania Steel Co., Steelton, Pa., as draftsman in the mechanical department. He was formerly connected with the Solvay Process Co., Syracuse, N. Y., as draftsman.

J. R. Bibbins, Mem.Am.Soc.M.E., has become Assistant Engineer to B. J. Arnold, Appraisal Division, Public Service Commission, New York. He was formerly associated with the Westinghouse Machine Company, East Pittsburg, Pa., as Engineer.

Grant D. Bradshaw, Jun.Am.Soc.M.E., has severed his connection with the Illinois Steel Company, and has opened an office at 77 Jackson Blvd., as a Consulting Engineer.

Wm. B. Brendlinger, Assoc.Am.Soc.M.E., has been made Pittsburg Manager of the Ingersoll Rand Co. He was until recently New York Manager of the company.

Paul R. Brooks, Jun.Am.Soc.M.E., formerly General Sales Manager of the Machine Sales Co., Peabody, Mass., has become Resident Engineer of the Union Bag and Paper Co., Sandy Hill, N. Y.

Donald S. Brown, Jun.Am.Soc.M.E., has entered the employ of the Westinghouse Electric and Manufacturing Company, Pittsburg, Pa. He was recently associated with the Dayton Hydraulic Machinery Company, Dayton, O., in the capacity of Sales Manager.

J. J. Brown, Mem.Am.Soc.M.E., has been elected vice-president and general manager of the Wheeler Condenser & Engineering Co., Carteret, N. J. Mr. Brown recently resigned his position as general Western sales manager of the International Steam Pump Co.

J. Norman Bulkley, Mem.Am.Soc.M.E., formerly Chief Engineer of the United Engineering Company, Ltd., Johannesburg, South Africa, has accepted a position with the General Mining and Finance Corporation. Johannesburg, South Africa, as Consulting Electrical Engineer.

Charles E. Burgoon, Mem.Am.Soc.M.E., formerly Assistant Inspector of Electric Light Plants, Treasury Department, Washington, D. C., has been made Assistant Inspecting Engineer, Isthmian Canal Commission, Washington, D. C.

S. N. Castle, Assoc.Am.Soc.M.E., formerly connected with Welch & Co., is now with the New York office of the General Electric Co.

Alexander G. Christie, Assoc.Am.Soc.M.E., Research Assistant in engineering at the University of Wisconsin, has been made Assistant Professor of steam engineering, in charge of the steam and gas engineering laboratories.

Chas. E. Davis, Mem.Am.Soc.M.E., has been appointed General Manager of the Warner Gear Co., Muncie, Ind. He was formerly Superintendent of the automobile department of the American Locomotive Company, Providence, R. I.

Charles Day, Jun.Am.Soc.M.E., officially represented the Franklin Institute on the occasion of the presentation of the gold medals of the Aero Club of America to Messrs. Wilbur and Orville Wright by President Taft, in the East Room of the White House on June 10.

Edward P. Decker, Mem.Am.Soc.M.E., has accepted the position of Engineer with the Kemiweld Can Co., Detroit, Mich. Until recently he held a similar position with Westinghouse, Church, Kerr & Co., New York.

William B. Dodds, Jun.Am.Soc.M.E., has entered the service of the Consolidated Light, Power and Ice Company, Joplin, Mo. He was formerly associated with the Denver Gas and Electric Co., Denver, Colo.

Paul Doty, Mem.Am.Soc.M.E., has recently been elected president of the local business league, St. Paul, Minn.

Arthur T. Doud, Jun.Am.Soc.M.E., has become Mechanical Engineer of the Hale-Kilburn Metal Company, Philadelphia, Pa. He was formerly with J. G. White & Co., in the capacity of Cost Engineer.

Alfred E. Forstall, Mem.Am.Soc.M.E., has been elected honorary alumni trustee of Lehigh University, South Bethlehem, Pa.

G. Clinton Gardiner, Jr., Mem.Am.Soc.M.E., has been appointed General Foreman of Motive Power, Hudson Division, P. R. R., Jersey City, N. J. He was until recently General Foreman of the Belvidere Division of the railroad, Lambertville, N. J.

Harry Gay, Assoc.Am.Soc.M.E., formerly associated with the N. Y. C. & H. R. R. R., New York, in the capacity of Assistant Engineer, has accepted a position with A. L. Drum & Co., Chicago, Ill., as Mechanical Engineer.

William Paul Gerhard, Mem.Am.Soc.M.E., is author of a book on Sanitation and Sanitary Engineering.

William H. Gerrish, Mem.Am.Soc.M.E., has accepted a position with the Columbian Rope Company, Auburn, N. Y., as Superintendent of the soft fiber department. He was until recently associated with the Travers Manufacturing Company, New York, as Superintendent.

Walter B. Gump, Jun.Am.Soc.M.E., recently of Los Angeles, Cal., is now permanently located at Tacoma, Wash., and engaged in general mechanical and electrical engineering.

F. W. Hollmann, Jun.Am.Soc.M.E., has resigned his position as Steam Engineer of the Maryland Steel Co., Sparrows Point, Md., in order to accept the position of Assistant Mechanical Engineer for the Carborundum Company, of Niagara Falls, N. Y.

First Lieutenant Mark L. Ireland, Jun.Am.Soc.M.E., has been transferred from the Frankford to the Watertown Arsenal, Watertown, Mass., connected with the ordnance department.

J. E. Johnson, Jr., Mem.Am.Soc.M.E., has accepted a position with the Republic Iron and Steel Company, as General Superintendent of the Thomas, Ala., Division.

J. C. Jurgensen, Assoc.Am.Soc.M.E., Chief Engineer and Superintendent, St. Regis Hotel, New York, has resigned his position to take the chair of engineering plant instruction at Columbia University next fall. A new course has been established for training students in the duties of engineers in charge of power plants.

R. R. Keely, Mem.Am.Soc.M.E., has recently been made professor of electrical engineering in the Nova Scotia Technical College, Halifax, N. S.

Prof. William Kent, Mem.Am.Soc.M.E., has resigned his position as General Manager of the Sandusky Foundry and Machine Company, Sandusky, O.

A. R. Kipp, Mem.Am.Soc.M.E., formerly Superintendent of Motive Power of the Wisconsin Central Railway, has been appointed Mechanical Superintendent of the Chicago division of the Soo Line.

Nisbet Latta, Jun.Am.Soc.M.E., until recently located at Seattle, Wash., has entered the mill and gas engine department of the Allis-Chalmers Company, West Allis, Wis.

Ralph A. Lee, Jun.Am.Soc.M.E., until recently in the employ of Geo. F. Hardie, New York, has accepted a position with Walter Kidde, New York, as Assistant Building Superintendent.

Ray D. Lillibridge, Assoc.Am.Soc.M.E., has taken into partnership William L. Rickard, with offices at 100 Broadway. New York. They will continue to devote themselves to technical publicity, the partnership being under the name of Ray D. Lillibridge.

B. D. Lockwood, Mem.Am.Soc.M.E., formerly Mechanical Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Railway, at Indianapolis, Ind., has resigned to accept a position as Assistant Chief Engineer of the Pressed Steel Car Company.

Daniel M. Luehrs, Jun.Am.Soc.M.E., presented a paper on the Ventilation of Steamships before the Toledo Society of Engineers, May 14.

H. J. Macintire, Jun.Am.Soc.M.E., formerly with the National Lead Company of Brooklyn, has resigned to take a position with the engineering department of Harvard University, attached to the instructing staff.

James H. MacLauchlan, Mem.Am.Soc.M.E., Engineer of the American Cement Engineering Company, Hudson, N. Y., has been transferred to the Yorktown, Va., office of the company.

James D. Macpherson, Mem.Am.Soc.M.E., has become Chief Engineer for Adolphus Busch, purchaser of the American Diesel Engine Company, St. Louis, Mo.

Mr. Macpherson was formerly Assistant Chief Engineer of the American Diesel Engine Company, New York.

Geo. B. Massey, 2d, Jun.Am.Soc.M.E., is author of Modern Gold Dredging, published in the August number of *Cassier's Magazine.*

Dr. Richard Moldenke, Mem.Am.Soc.M.E., Secretary of the American Foundrymen's Association, sailed in the middle of August, to attend the Copenhagen congress of the International Society for Testing Materials, and will go to Germany and France on professional business. He expects to return near the middle of October.

Chas. L. Newcomb, Jr., Assoc.Am.Soc.M.E., formerly located at San Francisco, Cal., has entered the service of the Deane Steam Pump Company, Holyoke, Mass.

E. W. Nicklin, Assoc.Am.Soc.M.E., has accepted a position with the Diamond Power Specialty Company, Detroit, Mich. He was formerly Mechanical Engineer of the Smith Engineering Company, Detroit, Mich.

Millard P. Osbourn, Jun.Am.Soc.M.E., formerly Mechanical Engineer with Warren Webster & Co., Camden, N. J., has opened an office under the name of Osbourn & Robinson, in the Pennsylvania Building, Philadelphia, Pa., where the firm will conduct a general business of supplying power plant equipment.

George A. Orrok, Mem.Am.Soc.M.E., is the author of Development of the Surface Condenser, which appeared in the June 1 issue of *Power and the Engineer.*

Dwight T. Randall, Mem.Am.Soc.M.E., late engineer-in-charge of fuel tests, Technologic Branch, United States Geological Survey, has associated himself with the Arthur D. Little Laboratory of Engineering Chemistry of Boston, in charge of the department of fuel engineering.

An article on Modern Power-Station Design, by H. de B. Parsons, Mem.Am. Soc.M.E., was published in the August issue of *Cassier's Magazine.*

A biographical sketch of Prof. Charles B. Richards, Mem.Am.Soc.M.E., was published in the June number of *Cassier's Magazine.*

M. E. Rupp, Jun.Am.Soc.M.E., will be located at Gatun, Canal Zone, in charge of erecting the steel and wooden forms for the Gatun Locks. He was formerly Computer-Estimator, Isthmian Canal Commission.

Geo. H. Shenberger, Jun.Am.Soc.M.E., has accepted a position with the Cast Thread Fitting and Foundry Co., Seneca Falls, N. Y., as Mechanical Engineer. He was formerly Draftsman with the Lehigh Coal and Navigation Co., Lansford, Pa.

Foster C. Slade, Assoc.Am.Soc.M.E., formerly with Westinghouse, Church, Kerr, & Co., New York, is now General Manager and Gas Engineer of the Willimantic Gas and Electric Light Company, Willimantic, Conn.

Ernest L. Smith, Jun.Am.Soc.M.E., has been made Sales Manager of the Grant-Lees Machine Company of Cleveland, O. He was until recently Western Representative of the Standard Roller Bearing Company of Philadelphia.

Carl A. Strom, Mem.Am.Soc.M.E., Mechanical Engineer of the steam shovel and dredge department of the American Locomotive Company, Richmond, Va., has been made Manager of the Rogers Works of the company at Paterson, N. J.

J. F. Taddiken, Jr., Jun.Am.Soc.M.E., has been transferred from the Grand Island, Neb., to the Chino, Cal., office of the American Beet Sugar Company.

Wm. Threlfall, Mem.Am.Soc.M.E., has resigned his position of General Manager of the Chapman Valve Co., Springfield, Mass.

Fred. E. Town, Mem.Am.Soc.M.E., has become Manager of the Otis Elevator Company, Pittsburg, Pa.

H. H. Vaughan, Mem.Am.Soc.M.E., has been elected President of the American Railway Master Mechanics' Association.

F. H. Vose, Jun.Am.Soc.M.E., formerly assistant professor of mechanical engineering in Washington University, St. Louis, Mo., has resigned to give similar instruction in the Case School of Applied Science.

George L. Wall, Mem.Am.Soc.M.E., Mechanical Engineer of the Lima Locomotive and Machine Co., Lima, O., has assumed the duties of Assistant General Manager.

S. S. Webber, Mem.Am.Soc.M.E., contributed an article on A High-Speed Corliss Engine, to the August issue of *Cassier's Magazine.*

Wm. H. Winterrowd, Jun.Am.Soc.M.E., formerly Roundhouse Foreman, L. E. A. & W. Ry., Alliance, O., has accepted a similar position with the Lake Shore and Michigan Southern Railway Co., Youngstown, O.

Edwin Yawger, Assoc.Am.Soc.M.E., presented a paper on the Leblanc Condenser before the June 23–25 convention of the Association of Iron and Steel Electrical Engineers.

HISTORY OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PRELIMINARY REPORT OF THE COMMITTEE ON SOCIETY HISTORY

CHAPTER X

CONTINUED GROWTH OF THE SOCIETY

244 Following upon the World's Fair of 1893, and perhaps largely because of it, the Society experienced a period of great activity and progress. The business depression gradually passed away, and with the commercial revival the membership of the Society increased, and the extent to which its members were engaged in the development of the country is reflected in the Society's activities as represented in its Transactions.

245 The reëlection of Eckley B. Coxe as President for the year 1894 retained in the chair a man already experienced in the work of the Society, while the general interest of the leading members gave added impetus to the efforts of the administration.

246 Following the custom, now become general, of basing his presidential address upon the department of engineering work with which he had been most closely identified, Mr. Coxe presented what proved to be a most valuable discussion of the possibilities of small sizes of anthracite coal for the generation of steam. A special interest attaches to this address at the present time (1909) because it has been assumed in many quarters that the realization of waste in the use of the great natural resource of coal is a very recent idea, whereas, prior to Mr. Coxe's work in this direction, which began in 1890, the waste of anthracite coal was very fully appreciated. Mr. Coxe himself

Under the direction of the Council the Committee on Society History has arranged to present the results of its investigations to the members of the Society. The Preliminary Report will appear in The Journal of the Society from month to month, and thus enable the matter to be open to comment during its completion. It is especially desired that any member who may be in the possession of facts or information bearing upon the various points as they are thus made public will communicate with the committee, in order that the final and completed report may have the advantage of the collaboration of the membership at large.

served upon a commission which reported to the State of Pennsylvania in 1893, and the situation as it was then presented convinced him that what has later been called "conservation" was a matter in which he as a coal operator was deeply interested. A quotation from Mr. Coxe's address will show very briefly the situation as it was presented to him:

247 "When I first remember the anthracite coal business, all the sizes below stove coal were considered of little or no value. Chestnut coal was used to a greater or less extent about the collieries for making steam, but much of it was thrown away. It gradually became a domestic fuel, and pea coal took its place for generating steam. This size is gradually coming into use (1893) for domestic purposes, and buckwheat coal is taking its place for steam. Two smaller sizes, known as rice and barley, are already being used to a large extent for the same purpose. The value, or cost, of these coals diminishes very rapidly with the size."

248 It was to increasing the value, considered as a steam fuel, without materially increasing the cost of these small sizes, that Mr. Coxe devoted much time and effort, and his address may well be examined by those who have been led to believe that the engineer needed to be encouraged to minimize waste in the use of coal.

249 Increased efficiency in the generation and use of power as well as in the conduct of machine-shop operations formed topics toward which many members of the Society were directing their attention, and the Transactions of 1894 contain some important papers on these subjects. Thus, at the New York Meeting of 1893, papers on steam economy predominated, these including contributions by Professors Aldrich, Carpenter and Jacobus on the team indicator, by Professor Carpenter on water-hammer in steam pipes, and by Mr. Pike on the influence of steam piping on the efficiency of steam plants. At this meeting Professor Thurston presented an important paper reviewing the contemporary economy of the steam engine, based upon the high performance of the Milwaukee pumping engine, and showing that a thermal efficiency of more than 19 per cent had been attained. Another paper of importance and of far-reaching influence presented at this meeting was that of F. W. Taylor, containing notes upon the actual behavior of belting in the machine shop, this paper having a direct bearing upon the methods afterwards so extensively undertaken to increase the output of machine tools by the introduction of the heavy cuts and feeds possible with high-speed steels.

250 The close of the year 1893 was marked by the first break in the ranks of the distinguished men who had served as president of the Society, George H. Babcock passing away on December 16. A man of broad professional culture, with many activities in the field of mechanical engineering, he will doubtless be best remembered for his part in the development of the water-tube boiler devised by himself and his lifelong associate, Stephen Wilcox.

251 The summer meeting of the year 1894, held from June 5 to 9, was the first convention of the Society to be held beyond the limits of the United States, the meetings occurring in the city of Montreal, Canada. Here the Society received a hearty welcome from the official representatives of the city government, the Canadian Societv of Civil Engineers, and the governors and faculty of the McGill University. Among the entertainments especially noteworthy at this meeting may be mentioned the reception at the residence of the Chancellor of McGill University, Sir Donald A. Smith, afterwards Lord Strathcona; and the garden party held at the Government House, Ottawa, by Lord Aberdeen, Governor General of the Province.

252 The second address of Eckley B. Coxe, delivered in the hall of McGill University, was very appropriately devoted to the subject of technical education, emphasizing the importance of the combination of technical and business training as essential to success in the engineering profession. The trend of the papers at the Montreal meeting again showed the attention which was being given to steam engineering. The discussions included papers on the steam jacket, the influence of compression on engine performance, the cylinder proportions of compound engines, and steam distribution. Papers on the cost of power, engine tests and engine details, showed the extent to which the principal prime mover occupied the thoughts of the members, and the activity of the discussions testified to the interest which the papers created.

253 The annual meeting of 1894, held as usual in the house of the Society in New York, contained, in its business discussions, some matters of much interest. During the winter of 1894, a series of monthly meetings had been held for the discussion of technical subjects, these meetings having taken place at the house of the Society, and the expenses being defrayed by subscription of the members interested.

254 An active discussion took place at this annual meeting as to the advisability of making such meetings a part of the regular work of the Society, the principal feature of the discussion being the desirability of avoiding the creation of an impression that the New York

members were receiving special advantages over distant members of the Society.

255 The result of the discussion was the adoption of a plan for the continuance of the meetings, but after a time these monthly gatherings were abandoned without any special action of the Society to that effect being taken.

256 A report of the committee on standard gauges for the thickness of wire and metal, presented a progress report advocating the use of a system based upon the actual thicknesses in the decimal system, as opposed to the older arbitrary numbering gage systems.

257 It is interesting to note that at this meeting it was reported that of the $32,000 issue of bonds disposed of by the Society in connection with the purchase of the house at No. 12 West Thirty-first St., New York, $19,000 worth had been acquired by the Society, by purchase, by surrender in exchange for life memberships, and by gift and bequest.

258 It has been noted, in commenting upon the papers presented at the various meetings, that certain departments of engineering work appeared to predominate at certain periods of time. At the annual meeting of 1894 the principal technical subject seemed to be that of the materials of construction, both as regards the resistances to various kinds of stresses, and as to the nature of those stresses. Among the more important of these papers may be mentioned the monograph of W. J. Keep upon tests of cast iron, this having been prepared for the Committee on Uniform Methods of Testing Materials, and being the first of the notable contributions of Mr. Keep to this subject. Other papers relating to the strength of materials include those of Professor Lanza, tabulating the results of tests made at the Massachusetts Institute of Technology upon full-sized spruce columns, by L. S. Randolph on the strength of railway car axles, and by G. M. Sinclair on steel forgings. At this meeting M. P. Wood presented the second of his extensive papers on rustless coatings for iron and steel, continuing the discussion commenced at the Montreal meeting. Other related papers treated of the proportions of springs, of rail pressure of locomotive driving wheels, and the stresses in the rims of pulleys and flywheels. At this meeting the election of E. F. C. Davis as President of the Society was announced.

THE HIGH-PRESSURE FIRE-SERVICE PUMPS OF MANHATTAN BOROUGH, CITY OF NEW YORK

DESCRIPTION OF PUMPS AND PUMPING SYSTEM WITH RESULTS OF TESTS

By Prof. R. C. Carpenter, Ithaca, N. Y.
Member of the Society

The object of this paper is to present a concise description of the high-pressure pumping system installed for fire service in the city of New York and the results of a test of the pumping machinery.

2 The system protects the district extending north from City Hall to Twenty-fifth Street, and east, approximately, from the North River to Second Avenue. It comprises about 55 miles of extra heavy cast-iron main, from 12-in. to 24-in. in diameter, with 8-in. hydrant branches; and two pumping stations so located that they never can be in the center of a conflagration. At the present time the pumping stations have a combined capacity of over 30,000 gal. per min. delivered at a pressure exceeding 300 lb. per sq. in.

THE SOURCE OF WATER SUPPLY

3 The supply of water is ordinarily obtained from the water mains of the city, which deliver Croton water to the stations at a pressure of from 14 lb. to 40 lb. per sq. in., depending upon the demand for water in that district. Both of the pumping stations are located close to tidal water and connections are made so that sea water can be obtained in case of difficulty with the Croton supply.

4 The advantage of the Croton water over salt water is that it is less likely to injure goods, and as the amount required for fire purposes is only a small percentage of that consumed for the daily supply of the city its use for fire protection makes no material difference from financial or insurance standpoints. As this is a matter of considerable importance data upon the quantity needed are given in the next paragraph.

To be presented at a meeting of The American Society of Mechanical Engineers.
All papers are subject to revision.

WATER REQUIRED FOR FIRE PURPOSES

5 The general impression that an enormous quantity of water is required for fire purposes is erroneous as shown by figures furnished to chief engineer I. M. de Varona by the fire department for the Boroughs of Manhattan and Brooklyn, years 1900, 1901, 1902, 1903 and 1904. These give the average quantity of water used for fire protection during these years in the Borough of Manhattan as 74,010,803 gal. per year, of which 31,056,928 gal. was river water. The daily average use of Croton water, therefore, for the above five years was 117,000 gal.

6 For the Borough of Brooklyn the average for five years was 43,705,568 gal. of which 19,010,928 gal. was river water; daily average, 67,000 gal.

7 During these five years the greatest quantity used in the Borough of Manhattan was 99,000,000 gal. in 1901, which included 69,500,000 gal. of river water, leaving 29,500,000 gal. for fresh water, and Mr. de Varona states (Report of the Department of Water Supply, Gas and Electricity): "Even if this quantity be made 100,000,000 gal. per year, by comparing it with the average daily consumption of about 300,000,000 gal. it will be seen that the total amount used for fire purposes would be only about one-third of the amount used for all purposes in 24 hr., forming, therefore, an insignificant percentage of the total consumption. The quantity needed for fire purposes (one-tenth of one per cent) may therefore be entirely neglected as a factor in determining the water supply of the city.

8 "The capacity of each of the pumping stations will be for the present 15,000 gal. per min. or 43,000 gal. per day for the two stations. By the installation of three additional units in each station, for which provision is made, this capacity can be increased in round numbers to 69,000,000 gal. per day.

9 "The two stations, with the motors and pumps as installed, have a total capacity in excess of that of all the fire engines in the Boroughs of Manhattan, the Bronx and Brooklyn working under normal conditions. This comparison assumes the engines to work on one line of 2½-in. hose, say 500 ft. long, under a pressure of, say 200 lb., and with the capacities as printed in the official blank forms of the reports of the fire department. It should furthermore be remembered that provision is made for the installation of still another pumping station."

MOTIVE POWER

10 The power for driving the pumps is transmitted electrically from several of the electric power and lighting systems located on Manhattan Island. As the stations of systems are widely separated and any or all of them are available for motive power the system of electric transmission was considered more reliable in the case of a large and general conflagration than power plants maintained directly at the pumping stations. Each station is provided with two independent sets of transmission lines located as far as possible beyond danger or injury in case of a great conflagration.

11 The cost of erecting and maintaining an independent power plant would have entailed a greater annual charge than the cost of the electric current; consequently the present arrangement is advantageous from a financial standpoint.

12 In addition to the charge per kilowatt for the current delivered there is a charge aggregating $90,000 per year for reserving the first right of use for the necessary generating machinery for this purpose. The total cost of maintenance of the system is estimated at $170,000 a year, which amount it is believed will be saved many times over by a reduction in insurance premiums now paid in the protected district.

13 The electric current is supplied at a pressure of 6600 volts from the following stations of the New York Edison Company, having the capacity indicated: 53 Duane Street, 7600 kw.; 115 East 12th Street, 1700 kw.; 45 West 26th Street, 400 kw.; 140th Street and Ryder Ave., 4000 kw.; Waterside Station No. 1 and No. 2, 196,700 kw. In addition there are feeders extending to the Brooklyn Edison Company stations which can be called on in case of an emergency demand.

14 The pumping stations are connected to 18 sub-stations, equipped with rotary converters and storage batteries, aggregating a capacity of 124,000 ampere hours at 135 volts, an enormous reserve.

15 Each station is connected with the main stations of the Edison Company by two 250,000 c.m. three-phase cables laid in ducts, and two independent reserve feeders extend to the sub-station system of the Edison Company. With all these precautions, interruption of the power supply would seem a physical impossibility.

THE DISTRIBUTION SYSTEM

16 The following information upon the distribution system is taken largely from the department report of Chief Engineer de Varona

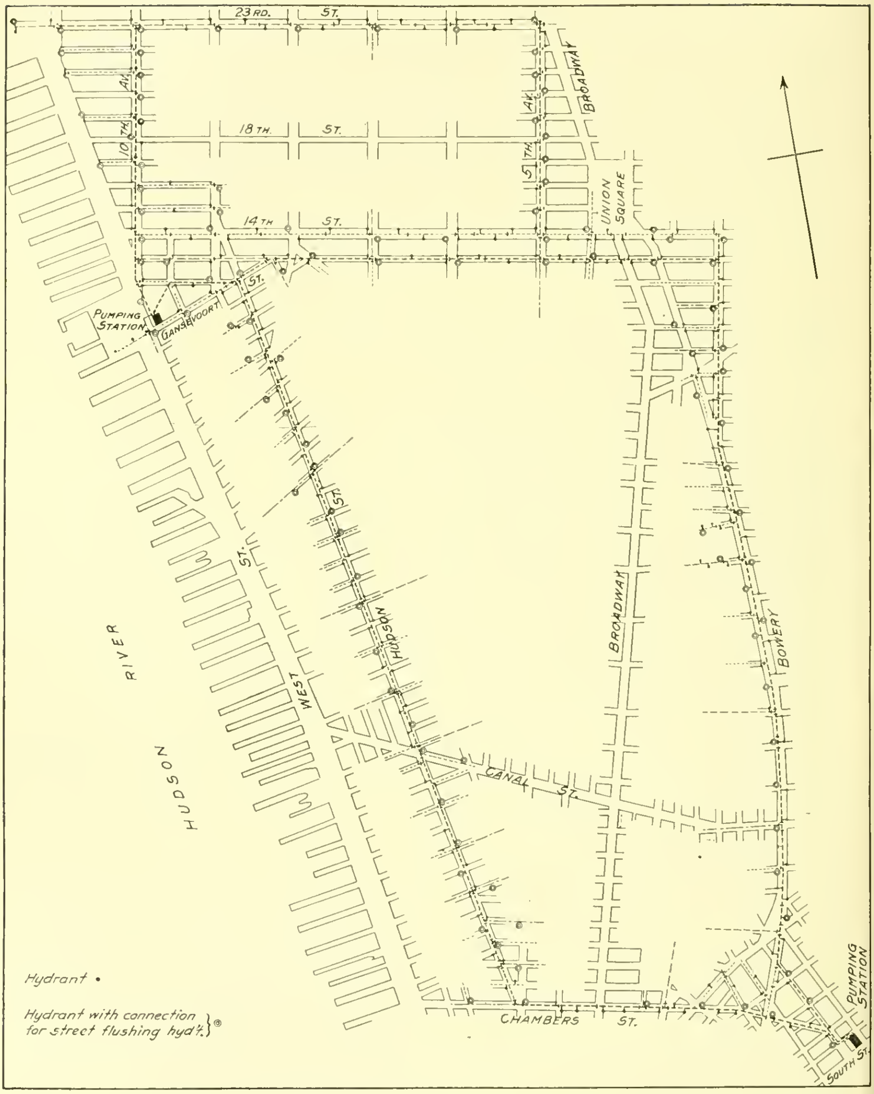

Fig. 1 Showing Location of Stations and Areas Covered by High-Pressure Pumping System

THE AREA INDICATED IS SERVED BY A SYSTEM OF MAINS RANGING FROM 24 IN. TO 12 IN. IN DIAMETER WITH 8-IN. HYDRANT CONNECTIONS for 1905. Fig. 1 shows the system to be bounded by mains laid on the north through Twenty-third Street; on the east, through Broadway to Fourteenth Street, through Fourteenth Street to Third Avenue, down Third Avenue to the Bowery, down the Bowery to Chambers Street; through Chambers Street on the south to West Street; and on the west through West Street.

17 The area actually protected is considerably greater than this as hose can be extended over a zone 600 ft. wide beyond the limits of the mains.

18 This district was selected as that in which the fire losses were the greatest and which most urgently needed fire protection. Plans have been prepared for the extension of the system southerly to the Battery, easterly as far as the East River, and, if necessary, northerly as far as Fifty-ninth Street, by the simple extension of the mains and probably the erection of a third pumping station.

19 The pipes, castings and hydrants were tested at a pressure of 450 lb. The specified allowance for leakage in a 10-min. test was at the rate of 4 gal. in 24 hr. for each lineal foot of pipe joint, equivalent to a leakage of 487,000 gal. for the whole system in 24 hr., which is somewhat over one per cent of the total specified pumping capacity now installed. The actual leakage on test was at the rate of 264,000 gal. per day or about six-tenths of one per cent of the pumping capacity. Considering the difficulties of construction and the high pressure the results attained were remarkable and reflect great credit on the engineer in charge.

20 There are sufficient hydrants so that if a block were on fire 60 streams of 500 gal. per min. each, or the full capacity of both stations, could be concentrated on a block with a length of hose not exceeding 400 ft. to 500 ft., assuming the use of 3-in. hose and 1¼-in. nozzles.

21 The layout of the mains at the stations both for suction and delivery is on the loop system; that is, the supply can be taken from either one of two mains, and the discharge is through either one or both of two mains. With this system even the breakdown of one of the discharge mains at the station would only slightly reduce the pressure at the fire and would not affect the capacity of the station, as the pumps would be capable of forcing their full discharge through the short length of a single 24-in. main made necessary by such an accident.

22 The mains are of cast-iron, bell and spigot pipe, of the thicknesses given in the following table:

Size of Pipe Inches	Thickness Inches	Unit Tensile Strain with 300 lb. pressure	Factor of Safety
24	$1\frac{7}{8}$	1920	0.4
20	$1\frac{1}{2}$	2000	10.0
16	$1\frac{1}{4}$	19.0	10.4
12	1	1800	11.1
8*	$\frac{7}{8}$	1371	14.6

* Used only for hydrant branches.

SUPPLY PIPING

23 At the South Street Station the fresh water supply is derived from two 30-in. lines, one connected at Chestnut Street to the 36-in. line on Madison Street, and the other connected at Pike Street to the 36-in. line on Division Street. These two main feeders, to which the two 30-in. lines are connected, increase to 48 in. in diameter and extend independently and directly to the Central Park Reservoir and are also reinforced by connections with the main feeders in this section of the city.

24 An auxiliary salt-water supply, consisting of two 36-in. pipes about 140 ft. long, brings the salt water from the East River to a suction chamber located directly in front of the pumping station. This suction is so constructed that the pipes are always below mean low water, thus insuring a supply at all times and avoiding the possibility of a break in the suction caused by air getting into the suction lines. On the river end of this suction there are constructed heavy bulkhead screens and in the suction chamber are two sets of bronze screens which are readily accessible for cleaning. From the suction chamber there are taken two 30-in. flanged mains to the duplicate set of mains in the pumping station proper. The vacuum in these 30-in. pipes is maintained by automatic electric vacuum pumps located on the pump room floor of the station.

25 At the Gansevoort Street Station the fresh-water supply is derived from two 30-in. mains, one connected at Twelfth Street to the 48-in. line on Fifth Avenue, which runs direct to Central Park Reservoir, and the other connected to the 36-in. line on Ninth Avenue at Little West 12th Street, which increases to a 48-in. line and runs also direct to the Central Park Reservoir. These two main feeders, in addition to having their supplies direct from Central Park Reservoir, are also reinforced by connections with the main feeders in this section of the city.

26 The salt-water suction lines for this station are practically identical with those for the South Street Station except that the 36-in. lines from the North River to the station are 650 ft. long.

PUMPING STATIONS

27 The two stations, known as the Gansevoort pumping station, located near Gansevoort Market on the North River, and the South Street station, located on the corner of Oliver and South Streets near the East River, are identical in construction and equipment. The buildings are of simple design, of steel fire-proof construction, with concrete foundations. The Gansevoort Street building, which is typical of both, is one story high with basement, 63 ft. 8 in. by 97 ft. 4 in. Each station is large enough for eight pumping units.

MACHINERY

28 There are now five units in each station consisting of Allis-Chalmers five-stage centrifugal pumps driven by Allis-Chalmers induction motors and the necessary auxiliary machinery. The motors and pumps are alike and their parts are interchangeable.

29 The pumps each have a specified capacity of 3000 gal. per min. of sea-water, working with a suction lift of 20 ft. and a delivery pressure of 300 lb. per sq. in. The actual capacity as indicated by a 24-hr. test was about 30 per cent in excess of that specified. The original specifications contemplated the use of six-stage pumps, with the expectation that sea-water would be used at each fire. Because of the facts already referred to (Par. 4), that the relative amount of water required for fire purposes is insignificant and that sea-water may do considerably more damage to goods than fresh water, a change in the specifications was agreed to whereby the pumps should work at best efficiency when receiving water from the Croton mains at a pressure on the intake side varying from 15 lb. to 40 lb. per sq. in.

30 To meet this new condition the pumps were all built with five stages. All the sea connections and priming machinery as originally contemplated were installed, so that sea-water can be pumped into the mains whenever desired. The effect of the change is merely to reduce the pressure head slightly in case sea-water is used.

ARRANGEMENT OF MACHINERY

31 The floor-plans of the buildings and general layout of machinery, piping, switchboards, etc., are shown in Fig 2. As will be seen

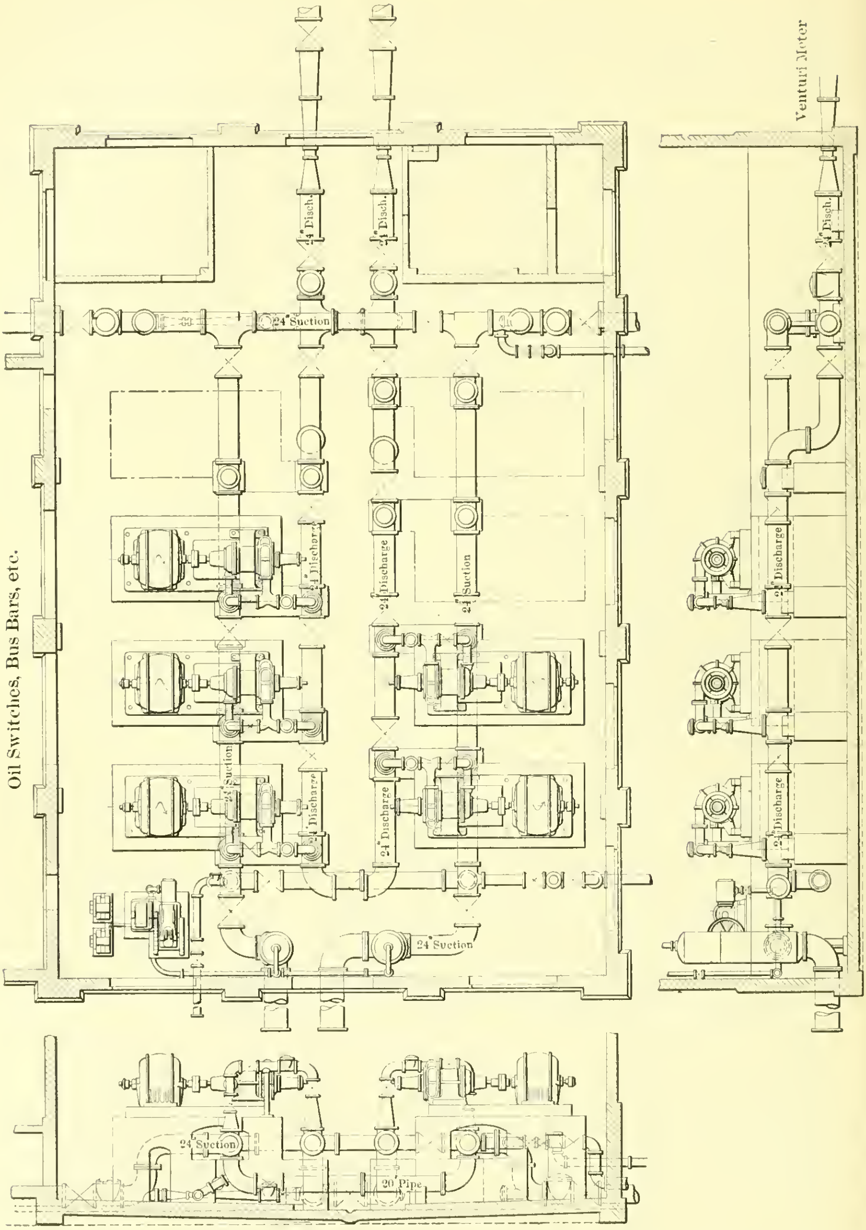

Fig. 2 Plan and Elevations Showing Arrangement of Hydraulic and Electrical Apparatus in Pumping Stations

space is provided for three additional units. Working detail plans of the machinery were furnished by the contractor. The arrangement shown in Fig. 2 is the same for both stations, the only difference being that the switchboard and office in the South Street station are on different sides of the building as compared with the Gansevoort station.

32 The motors and pumps, with suction and delivery branches, are located on the main floor of the pump room. The switchboard and switchboard apparatus are placed in an enclosed two-story and basement gallery.

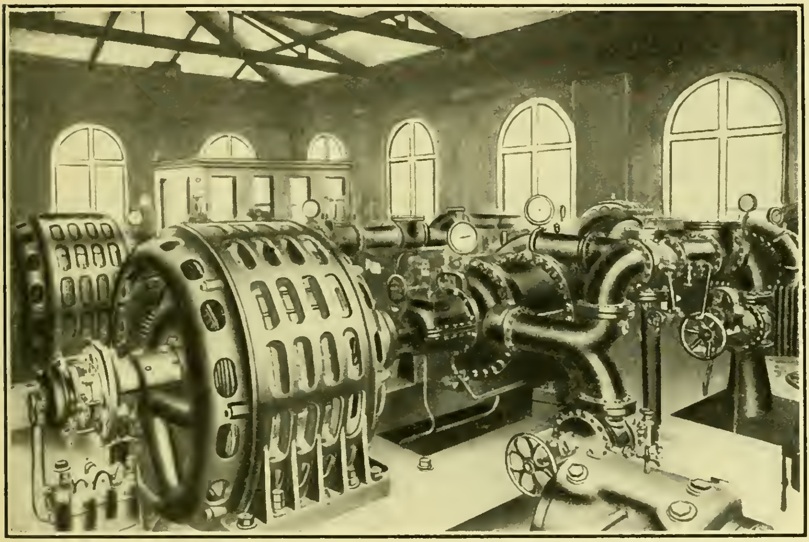

Fig. 3 Interior View of Station

33 The four high-tension feeders and all other wires entering the building are brought in through the gallery basement. All terminal work on the entering wires is located in the basement. On the first floor of the gallery, which is approximately on the same level as the pump-room floor, are placed the oil switches, with their controlling and protective devices, fire-proof cells and compartments.

34 The operating switchboard is conveniently located in the enclosing wall of the gallery, and is so placed as to allow a man standing on the pump-room floor to perform all the operations necessary for controlling the apparatus in the station. The bus bars,

with their fireproof compartments, are placed on the second floor of the gallery.

MOTORS FOR CENTRIFUGAL PUMPS

35 Each pump is direct-connected to its motor by a flexible coupling which takes care of any variation from alignment. The motors are of the constant-speed induction type, 3-phase, 25-cycle, 6300-volt to 6600-volt, designed to operate at about 740 r.p.m. The motors are of the wound rotor type, and in starting an iron grid resistance is connected in the secondary circuit and gradually cut out by means of a [handwheel on the motor switchboard panel. When the resistance is all cut out the rotor is automatically short circuited and operated by specially constructed solenoids which are operated by a small switch mounted directly on the shaft of the handwheel above referred to. An interlocking arrangement prevents the operator from closing the switch connecting the motor to the line while the motor is short-circuited.

36 The specifications required the motors to have sufficient starting torque to attain full speed between 30 sec. and 45 sec. after starting, with a current not exceeding 150 per cent of that used when the motor is working under full speed. Each motor was required to develop not less than 800 b.h.p. when using current of 6300 volts, 25 cycles, and under these conditions to have an efficiency not less than 92 per cent, a power factor not less than 93 per cent, and a motor slip not in excess of 2 per cent. At three-quarters load the efficiency was not to be less than 92 per cent and the slip not to exceed 1.5 per cent. It was specified that the temperature of the motors should not rise more than 40 per cent on a 24-hr. test at full load, when measured by a thermometer, the air in the room being 25 deg. cent.

37 Prof. Geo. F. Sever of Columbia University tested two of the motors in the shops of the contractor and found them to meet the specifications and to have a full-load efficiency of 93.2 per cent. The other motors were inspected and found to be alike and were assumed to have the same efficiency. The motors were also tested for temperature rise at the time of the official test to be described later.

MOTORS FOR AUXILIARIES

38 Direct-current motors of 240 volts are provided to operate the various gate valves in the station and the piston pumps employed for maintaining a vacuum on the salt-water suction lines.

PUMPS

39 As previously stated the pumps were finally constructed with five stages, each to give a pressure of somewhat over 60 lb. per sq. in., making the combined pressure of the five stages about 300 lb. per sq. in. above the intake pressure, which is the maximum working pressure of the stations at normal speed of 740 r.p.m. This type of pump is the simplest now on the market for pumping water either against a high head or low head, and this simplicity was the deciding factor which led to the selection of this style of machinery.

40 The pumps are water-balanced by a piston connected to the last impeller and upon which the water pressure acts, but should any additional end-thrust occur, it would be taken up by the ball bearing provided in the outboard bearing. This ball bearing consists of two rings of 1½-in. diameter steel balls and is water-cooled. The balancing piston is fitted very loosely in order to keep the friction losses small, and as a result a considerable amount of water leaks past it into a chamber at the end of the pump, which is provided with a discharge pipe and valve leading into the suction. By adjusting the valve in this pipe the difference of pressures on the piston can be regulated as desired. The bearings are of the ring-oiled type and are separated from the pump casing by packing glands which prevent foreign matter from entering the bearings. The impellers are of bronze and the shaft of forged steel. All parts of the runners and diffusion vanes are thoroughly lubricated by oil cups on the base of the pumps, shown in Fig. 4. A feature is the wide base which allows the pump barrel to set low, giving stability.

41 Each combined unit is equipped with automatic and hand control. The pumps are kept primed for instant service and the simple operation of a switch on the main switchboard starts the machine and gives full pressure in about 30 sec.

PRESSURE REGULATING VALVES

42 A combined regulating and relief valve is interposed between the discharge pipe and the suction pipe of each pump, and set to regulate the discharge of each pump to any predetermined pressure. When the volume of the water discharged by the pump is in excess of that forced into the system, this valve acts as a relief valve and by-passes this excess into the suction to the pump, the pressure on the main distribution system remaining at the predetermined point.

When no water is forced into the distribution system all of the water discharged from the pump is then by-passed into the suction.

43 The pressure-regulating valves were made by the Ross Valve Mfg. Co., of Troy, N. Y., and much of the practical success of the station has been due to the accuracy with which they maintain any desired pressure. The construction of these valves at this particular time cannot, however, be given with fairness to the manufacturers.

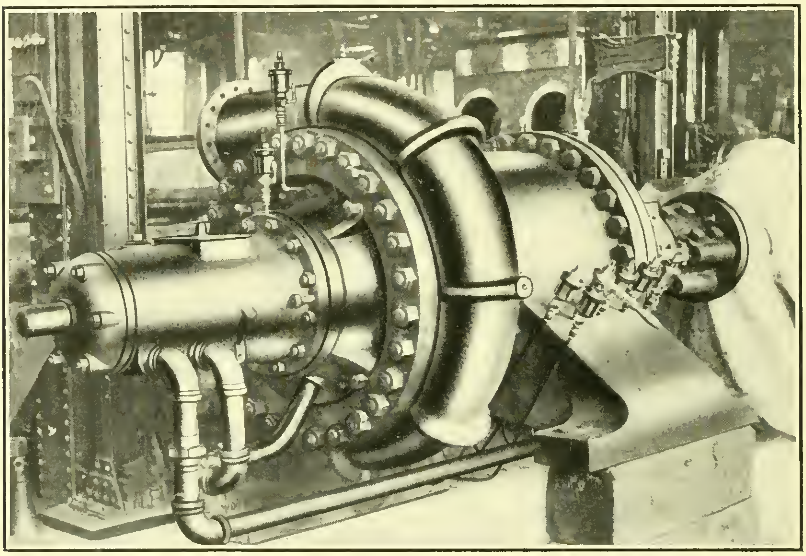

FIG. 4 MULTISTAGE PUMP, CAPACITY 3000 GAL. PER MIN.; MAXIMUM HEAD, 300 LB. PER SQ. IN.

PRIMING APPARATUS FOR SALT-WATER SUCTION LINES

45 The priming apparatus in each station consists of three motor-driven vacuum pumps, each arranged to maintain automatically a vacuum of 26 in. in the suction lines. These pumps are of the piston single-action type, one having a displacement capacity of 300 cu. ft. per min. for a piston speed of 200 ft. per min. and each of the others a displacement capacity of 50 cu. ft. with a piston speed of 160 ft. per min.

46 An air-collecting chamber is connected to each of the salt-water suction lines and equipped with water-gage glass and vacuum gage. The air-suction piping between the air chambers and the air pumps is provided with a vertical loop sufficiently high to prevent

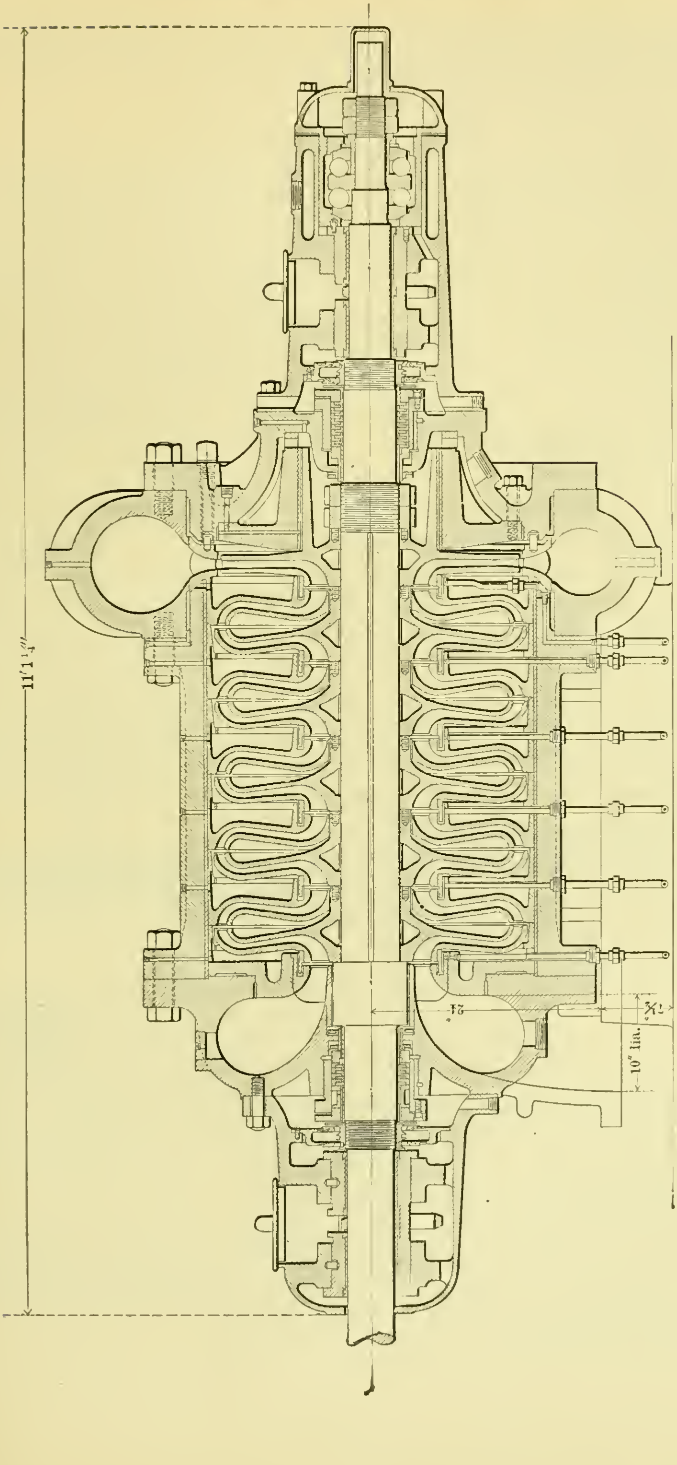

Fig. 5 Cross-Section of Five-Stage, High-Lift Centrifugal Pump

water being carried over to the pumps. The air pumps are interconnected to each air chamber.

VENTURI METERS

47 Venturi meters for measuring the discharge of water from the station and from one main to the other were set by the contractor on each discharge main and on the cross-connecting main. The meters of the discharge main are 24 in. in diameter and on the cross-over main 12 in. in diameter. These meters were standarized under the direction of F. N. Connet, chief engineer of the Builders Iron Foundry, Providence, R. I., and were provided with dial-indicating gages and also chart-recorders graduated to indicate the flow in gallons per minute; and in addition with an integrating meter which registers the total flow in gallons.

48 The readings during the test were taken by a mercury manometer, graduated to show the capacity in thousands of gallons per minute. For this purpose a Venturi manometer was attached with a temporary connection to each of the 24-in. Venturi tubes. The manometer gave essentially the same reading as the indicating dial on the main register.

49 The Venturi manometer is practically a tube partly filled with mercury, one side of which communicates with the upstream pressure chamber of the meter tube, while the other communicates with the throat-pressure chamber. The connections with the manometer are indicated in the diagram, Fig. 6.

50 The sketch shows a 24-in. high-pressure meter tube, its register-indicator-recorder and manometer. The instruments and meter tube are drawn to scale, but in the pumping station the meter tube is about 75 ft. distant from the instruments.

TESTS OF MACHINERY

51 The specifications for the pumping system provided for an endurance test of each motor and pump lasting 24 hr. without stop, during which time the capacity and efficiency of the pumps and motors was to be determined. The tests were to be in charge of an expert appointed by the commission.

52 The specifications provided for making the test with sea water, but this was later changed to a test with Croton water under the conditions of actual use. In view of this change the contractor increased the efficiency guarantee from 70 to 71 per cent.

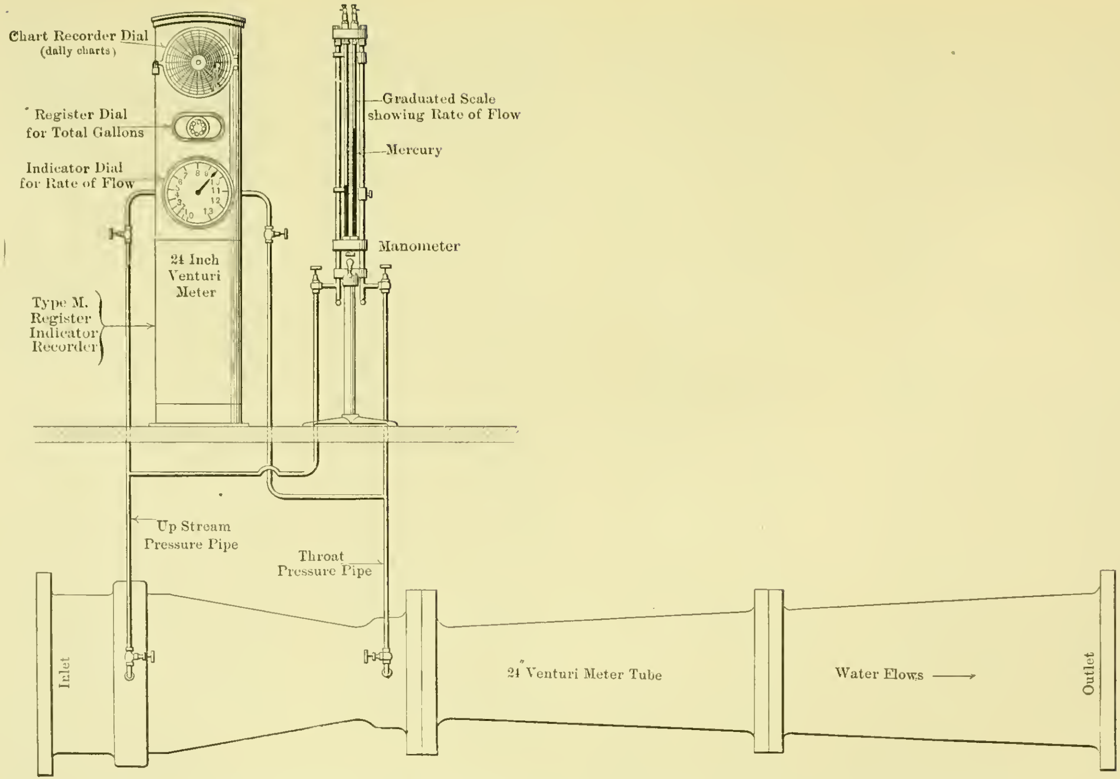

FIG. 6 ARRANGEMENT OF MANOMETER AND ITS CONNECTIONS TO THE VENTURI METER

53 The original specifications called for a capacity of 3000 gal. of sea water per minute against a discharge pressure of 300 lb. per sq. in. and a suction lift not exceeding 20 ft. The total increment of pressure is equivalent to 308.66 lb. from the intake to the delivery side. The Croton pressure varies at the stations in different parts of the day from about 40 lb. to 13 lb. per sq. in. and is affected by the amount of water being drawn from the mains. Consequently, to meet the requirements, the delivery pressure would need to be 308.66 lb. in excess of the intake pressure. There is also a further correction from the fact that sea water is heavier than fresh water and this correction under maximum conditions might amount to 2.5 per cent.

54 The specifications further provided that the brake horse-power developed by the motors under test should be computed from the electrical energy supplied to them, corrected for the efficiency of the motors as determined by the test. They further provided that if the aggregate of all stops exceeded one hour for any motor the test for capacity for such motor was to be run over again for a period of 24 hr.

55 The specifications also provided that the pumping capacity of the apparatus and the efficiency of the pumps should be based on the minimum rate of pumping during any eight consecutive hours of the endurance test, during which none of the motors were stopped.

56 The discharge of the pumps was determined by the reading of the Venturi meters, one of which was located in each discharge line. These readings were under the direction of F. N. Connet, and were checked by observers representing the contractors and also the city.

57 The modified specifications also required that the efficiency of *each pump* should be not less than 70 per cent and its capacity not less than 3000 gal. of sea water when lifted to a pressure equivalent to 308.66 lb. To determine whether the requirement was met, a separate test of each pump was required.

58 The efficiency of the pumps was computed by dividing the horse-power output of the pumps by the horse-power input as received from the motors. The horse-power input was computed as follows:

$$\text{h.p. input} = \frac{\text{total watts}}{746} \times \text{efficiency of motors (93.2 per cent).}$$

The horse-power output was computed as follows:

h.p. output

$$= \frac{\text{wt. per gal. (8.34} \times \text{2.31 head in pounds} \times \text{no. of gal. per min.}}{33{,}000}$$

OLIVER STATION TEST

59 The test of the South Street Station was begun at 12:30 p.m. on September 2, 1908, after about 2 hr. of preliminary running for the purpose of adjusting the delivery pressure; it was continued without interruption for 24 hr. With the exception of a short stop of motor No. 2 which was shut down from 2:11 to 2:41 a.m., September 3, to remedy a slight defect in the insulation of the field coils no pump was stopped. During the time No. 2 was stopped the pressure on the delivery mains fell to about 300 lb.; during the remainder of the test the pressure was maintained at or above the contract requirement, as will be noted by consulting the last column of Table 1.

60 The average results for each hour for the 24-hr. test of all four motors are given in Table 2. It will be noted that the delivery every hour was largely in excess of the contract requirement of 15,000 gal. The smallest delivery for eight consecutive hours occurred at the last part of the test, when the average capacity, as shown by the readings, was 18,447 gal. per min., and the average efficiency was 72.2 per cent. During this time the average pressure pumped against was 314.5 lb., or an excess of about 6 lb. over contract requirement.

61 It will be noted from the last column of Table 2 that there is considerable variation in the efficiency; that during the first hour the efficiency was less than 70 per cent, whereas during the third, fourth and fifth hours the efficiency exceeded 75 per cent. This variation in efficiency was doubtless caused by variation in the amount of water by-passed from the pressure to the suction side of the pump over the balanced piston and through the bearings, and possibly during the first hour by the discharge of some water through the relief valve which was pumped but not metered. The valves for regulating the differential pressure on the balance pistons were nearly closed during the third, fourth and fifth hours of the South Street Station test, but were opened the normal amount for the remaining portion of the test. The amount of water which may leak for maximum difference of pressure around the balance piston of any pump without passing through the meter could not be accurately determined but was estimated to be in excess of 4 per cent. Hence it appears that slight changes in the opening of the valve controlling the differences of pres-

sure at this piston must materially affect the efficiency. The normal opening of this valve appears to correspond to an efficiency of about 72.5 per cent.

62 During the test of the South Street Station all the bearings ran cool with the exception of those on No. 6 pump, which heated up during the third and fourth hours but were brought to a normal condition without stopping the pump or reducing its load by the application of lubricants and cooling water.

TABLE 1 HOURLY AVERAGE OF READINGS OF DISCHARGE AND INJECTION GAGES ON PUMPS[1]

South Street Pumping Station, September 2 and 3, 1908

Hour	Pump No. 6		Pump No. 4		Pump No. 2		Pump No. 1		Pump No. 3		Average		Net Pressure
	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	Lb.
12:30– 1:15	335.0	21.8	332.3	22.6	329.8	22.5	331.0	24.0	332.9	23.3	332.2	22.8	309.4
1:30– 2:15	347.2	20.9	347.0	22.2	345.5	22.1	343.8	22.6	346.2	22.1	345.9	22.0	323.0
2:30– 3:15	345.0	20.9	343.8	21.8	342.8	22.1	341.0	22.5	343.4	21.8	343.2	21.8	321.4
3:30– 4:00	344.2	20.9	343.8	21.9	340.3	22.3	339.8	22.6	342.2	21.9	342.1	21.9	320.2
4:30– 5:00	341.7	21.1	341.8	21.9	340.8	22.6	339.3	23.1	342.2	22.4	341.2	22.2	319.0
5:30– 6:00	336.2	22.4	336.3	22.9	335.3	23.8	333.3	25.3	335.7	23.6	335.4	23.6	311.8
6:30– 7:00	337.2	24.4	336.8	24.9	334.8	25.3	333.8	26.3	335.7	24.9	335.7	25.2	310.5
7:30– 8:00	339.7	25.1	337.8	25.9	335.8	26.6	334.8	27.3	337.7	25.9	337.2	26.2	311.0
8:30– 9:00	341.2	26.6	339.3	26.9	338.3	27.3	337.3	28.8	338.7	27.1	339.0	27.3	311.7
9:30–10:00	344.7	27.6	342.8	27.9	341.8	28.6	343.3	29.3	344.7	27.9	343.5	28.3	315.2
10:30–11:00	342.2	28.9	341.3	29.1	340.3	29.3	340.8	30.8	342.7	29.6	341.5	29.5	312.0
11:30–12:00	343.7	30.4	344.3	29.9	343.3	30.3	342.3	32.1	343.7	30.6	343.5	30.7	312.8
12:30– 1:00	345.7	30.6	347.3	30.1	347.3	30.8	345.8	32.6	347.9	31.4	346.8	31.1	315.7
1:30– 2:15	334.0	30.9	334.5	30.6*			332.6	33.1	333.9	31.4	333.7	31.5	302.2
2:30– 3:00	332.4	31.1	331.0	30.9			330.8	32.8	332.2	31.6	331.6	31.6	300.0
3:30– 4:00	349.2	31.4	348.3	31.1	346.3	31.6	347.3	33.3	349.2	31.6	348.1	31.8	316.3
4:30– 5:00	347.2	31.1	346.8	30.9	346.3	31.3	345.8	32.8	349.4	31.4	347.1	31.5	315.6
5:30– 6:00	346.7	28.6	346.3	28.4	345.3	29.3	345.3	30.6	348.2	29.4	346.4	29.3	317.1
6:30– 7:00	342.2	27.6	342.3	25.4	340.3	26.1	340.3	27.1	341.2	26.1	341.3	26.5	314.8
7:30– 8:00	332.7	21.6	332.3	22.1	330.3	22.6	329.3	24.1	331.2	22.6	331.2	22.6	308.6
8:30– 9:00	332.7	20.9	332.3	21.4	331.3	22.1	329.3	22.6	331.2	21.6	331.4	21.7	309.7
9:30–10:00	331.7	20.6	332.3	20.9	328.8	21.8	328.3	22.8	331.2	22.1	330.5	21.6	308.9
10:30–11:00	334.2	21.4	336.8	21.6	332.8	22.3	331.8	23.3	336.2	22.4	334.4	22.2	312.2
11:30–12:30	336.0	21.9	338.0	21.9	333.6	22.6	334.0	23.8	337.7	22.6	335.9	22.6	313.3

[1] Readings corrected for error, and to center of pumps.

* Pump No. 2 shut down from 2:11 to 2:41 account of motor.

63 It will be noted from Table 2 that the average results of the 24-hr. test of the South Street Station exceeded the contract requirements in capacity, pressure head and efficiency.

64 The horsepower delivered by the motors during the test averaged for the 24 hr. about 920 or about 15 per cent above rating, without excessive heating.

65 Immediately after the close of the endurance test of 24 hours, a short test was run on each motor separately, which was continued long enough after uniform results were shown to obtain 12 to 15 readings. This test was run for the purpose of ascertaining whether there were deficiencies in any of the individual motors, and to meet the requirements specified in the printed specifications for the work, viz: that each pump should be free from defects, should have a capacity of 3,000 gal. per min. and an efficiency not less than 70 per cent. The results of this test showed that the individual pumps operated singly had an efficiency from 4 per cent to 6 per cent in excess of

TABLE 2 COMPUTATION OF PUMP EFFICIENCIES

South Street Pumping Station, September 2 and 3, 1908

Hour Beginning	h.p.m.	Total kw. per hr.	Total h.p. from motors (input)	Gal. per min.	Net pressure lb.	h.p. delivered	Efficiency per cent
12:30 p.m.		3875	4841.4	18334	309.4	3311.6	68.6
1:30	757.0	3851	4811.4	18634	323.9	3523.6	73.2
2:30	755.0	3829	4784.0	19217	321.4	3605.7	75.4
3:30		3819	4771.5	19220	320.2	3592.8	75.3
4:30	755.0	3811	4761.5	19145	319.0	3565.4	75.0
5:30		3837	4794.0	18995	311.8	3457.6	72.1
6:30	755.0	3818	4770.3	18970	310.5	3438.7	72.2
7:30	755.0	3815	4767.5	18980	311.0	3446.0	72.3
8:30	757.0	3863	4826.4	19020	311.7	3461.1	71.6
9:30	756.0	3868	4830.2	19120	315.2	3518.3	72.8
10:30	757.0	3873	4838.9	19095	312.0	3478.1	72.1
11:30	756.5	3859	4821.4	19120	312.8	3491.6	72.4
12:30 a.m.	757.0	3870	4835.2	19175	315.7	3534.1	73.0
1:30	756.5	3672	4587.8	18790	302.0	3315.0	72.5
2:30	757.0	3667	4581.6	18776	300.0	3288.4	71.5
3:30	757.0	3890	4860.2	19190	316.3	3543.5	72.8
4:30	757.5	3891	4861.4	19160	315.6	3530.2	72.6
5:30	754.7	3861	4823.9	19110	317.1	3337.7	73.2
6:30	757.0	3865	4828.9	19005	314.8	3492.7	72.4
7:30	754.7	3706	4630.4	18710	308.6	3370.8	73.0
8:30	745.6	3659	4571.5	18100	309.7	3272.5	71.5
9:30	745.6	3651	4536.5	17890	308.9	3226.2	71.5
10:30	745.0	3619	4521.6	17795	312.2	3243.4	71.8
11:30	747.0	3618	4519.1	17806	313.3	3256.8	71.8
Average	756.1						72.5

Average efficiency, 1st period of 8 hr. = 73.0 per cent.
Average efficiency 2nd period of 8 hr. = 72.3 per cent.
Average efficiency 3rd period of 8 hr. = 72.5 per cent.

No. of cycles per sec. 12:30 p.m. to 6:30 a.m. = 25.5
No. of cycles per sec. 6:30 a.m. to 12:30 p.m. = 25.0

the average when operated together, and that the capacity for the specified discharge pressure was considerably in excess of the requirement of the specification. It is, I believe, generally the case that individual centrifugal pumps delivering water into a main singly show a greater efficiency by from 4 per cent to 6 per cent than the same pumps delivering together into a single main, due probably to less loss in eddy currents and friction head, etc.

TABLE 3 HOURLY AVERAGE OF READINGS OF DISCHARGE AND INJECTION GAGES ON PUMPS

Gansevoort Street Pumping Station, September 5 and 6, 1908

Hour	Pump No. 6		Pump No. 4		Pump No. 2		Pump No. 1		Pump No. 3		Average		Net Pressure Lb.
	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	Disc.	Inj.	
9:45–10:30	342.4	24.7	342.6	25.6	344.8	24.9	346.9	25.2	345.1	25.3	338.4	25.1	319.3
10:45–11:30	347.4	24.7	347.1	25.7	345.4	25.2	348.4	25.4	346.4	25.2	346.9	25.2	321.7
11:45–12:15	348.9	24.9	348.9	26.2	347.9	25.7	349.4	25.9	347.9	25.9	348.6	25.7	322.9
12:45– 1:15	351.4	25.7	350.9	27.7	350.1	26.7	352.4	26.9	350.4	26.9	351.0	26.8	324.2
1:45– 2:15	352.4	25.7	352.4	27.4	350.9	26.7	353.4	26.7	351.4	26.9	352.1	26.7	325.4
2:45– 3:15	352.9	25.7	352.9	27.7	351.4	26.9	354.9	27.2	351.4	27.2	352.7	26.9	325.8
3:45– 4:15	353.9	26.4	353.9	28.2	353.4	27.7	355.4	27.4	353.4	27.9	354.0	27.5	326.5
4:45– 5:15	354.4	26.9	354.4	28.7	353.4	27.9	355.9	28.2	353.4	28.7	354.3	28.1	326.2
5:45– 6:15	349.9	27.4	349.9	29.7	350.4	28.7	351.9	28.9	350.9	29.2	350.6	28.8	321.8
6:45– 7:15	349.9	28.4	348.9	30.2	349.4	29.2	351.4	29.2	349.4	29.4	349.8	29.3	320.5
7:45– 8:15	351.9	28.9	350.9	30.7	350.4	29.7	352.4	29.2	349.9	29.9	351.1	29.7	321.4
8:45– 9:15	351.9	29.7	351.9	30.9	350.6	29.7	353.4	29.9	350.9	30.7	351.7	30.2	321.5
9:45–10:15	352.4	29.7	354.4	30.9	351.4	30.2	353.4	30.4	352.9	30.9	352.9	30.4	322.5
10:45–11:15	354.4	30.4	353.9	31.2	353.4	30.2	354.9	30.9	353.4	31.2	354.0	30.8	323.2
11:45–12:15	354.4	31.2	353.4	31.7	352.9	31.2	353.9	31.7	352.9	31.2	353.5	31.4	322.1
12:45– 1:15	353.9	31.2	352.4	31.7	352.9	31.2	354.9	31.7	353.4	31.2	353.5	31.4	322.1
1:45– 2:15	352.4	31.2	351.9	32.2	352.9	31.2	354.4	31.9	353.4	31.2	353.0	31.5	321.5
2:45– 3:15	350.4	31.7	349.4	32.2	349.4	31.4	351.9	32.2	350.4	31.7	350.3	31.8	318.5
3:45– 4:15	350.9	32.2	350.4	32.7	348.9	31.2	351.4	32.7	348.4	31.4	350.0	32.0	318.0
4:45– 5:15	350.9	31.9	350.4	32.4	350.4	31.2	352.9	32.2	349.9	31.2	350.9	31.8	319.1
5:45– 6:15	352.4	31.2	351.9	32.2	352.4	30.7	353.4	31.7	351.9	31.4	352.4	31.4	321.0
6:45– 7:15	350.9	29.9	349.9	31.2	349.4	29.9	351.9	30.7	349.4	30.9	350.3	30.5	319.8
7:45– 8:15	349.4	28.7	349.4	29.7	347.4	29.4	349.9	29.2	347.9	29.4	348.8	29.3	319.5
8:45– 9:45	348.1	27.4	347.7	28.9	346.4	28.0	348.4	28.0	346.4	28.5	347.4	28.2	319.2

Readings corrected for error of gage and to center of pumps.

GANSEVOORT STATION TEST

66 The endurance test of the Gansevoort station with all the pumps in operation was begun at 9:45 a.m., September 5, after the pumps had been operated for about 20 min. giving uniform results. The test was continued for 24 hr. The method of testing and the

TABLE 4 COMPUTATION OF PUMP EFFICIENCIES

Gansevoort Street Pumping Station, September 5 and 6, 1908

Hour Beginning	h.p.m.	Total kw. per hr.	Total h.p. from motors (input)	Gal. per min.	Net pressure lb.	h.p. delivered	Efficiency per cent
9:45 a.m.	740	3671	4586.5	17107	319.3	3188.9	69.5
10:45	749	3589	4484.2	17310	321.7	3251.0	72.5
11:45	750	3591	4486.7	17290	322.9	3259.3	72.9
12:45	752	3591	4486.7	17280	324.2	3270.5	72.9
1:45 p.m.	752	3604	4502.9	17285	325.4	3283.6	72.9
2:45	753	3604	4502.9	17315	325.8	3293.3	73.3
3:45	753	3630	4535.3	17345	326.5	3306.1	72.9
4:45	753	3685	4604.0	17670	326.2	3365.0	73.1
5:45	756	3696	4617.9	17855	321.8	3354.4	72.6
6:45	756	3661	4574.0	17825	320.5	3335.2	73.4
7:45	754	3676	4592.9	17775	321.4	3335.2	73.3
8:45	753	3685	4604.0	17755	321.5	3332.5	72.8
9:45	755	3657	4569.0	17720	322.5	3336.2	72.9
10:45	755	3693	4614.2	17755	323.2	3350.1	72.7
11:45	756	3704	4627.9	17830	322.1	3352.8	72.6
12:45 a.m.	756	3753	4689.0	18195	322.1	3421.4	73.0
1:45	756	3760	4697.8	18310	321.5	3436.6	73.3
2:45	756	3735	4665.5	18315	318.5	3405.5	73.0
3:45	755	3725	4654.0	18290	318.0	3395.5	73.0
4:45	756	3743	4677.6	18315	319.1	3411.9	73.0
5:45	756	3784	4727.9	18330	321.0	3435.0	72.7
6:45	755	3747	4681.6	18315	319.8	3419.4	73.0
7:45	755	3723	4656.5	18255	319.5	3405.0	73.1
8:45	755	3722	4655.3	18189	319.2	3389.5	72.8
Average	753.6						72.9

Average efficiency, 1st period of 8 hr. = 72.9 per cent.
Average efficiency, 2d period of 8 hr. = 73.0 per cent.
Average efficiency, 3d period of 8 hr. = 72.9 per cent.

No. of cycles per sec. 9:45 a.m. to 2:45 p.m. = 25.00
No. of cycles per sec. 2.45 p.m. to 4.45 p.m. = 25.25
No. of cycles per sec. 4:45 p.m. to 6:45 p.m. = 25.50
No. of cycles per sec. 6:45 p.m. to 7:45 p.m. = 25.00
No. of cycles per sec. 7:45 p.m. to 9:45 p.m. = 25.25
No. of cycles per sec. 9:45 p.m. to 9:45 a.m. = 25.50

various observers were the same as described in reference to the South Street Station.

67 For the Gansevoort station the efficiency average for 24 hr. was 72.9 per cent, with a variation (excepting the first hour) of less than one-half of 1 per cent. It fell below 70 per cent during the first hour, which was due to the opening of an automatic relief valve on pump No. 2, which discharged some of the water into the suction before it had been metered. For that reason the efficiency during the

first hour has not been considered in determining the performance of the pumps.

68 The least capacity during the eight consecutive hours when all the water pumped passed through the meters occurs from 10.45 a.m. to 6.45 p.m. The average capacity during this time is 17,419 gal. or about 16.5 per cent above that guaranteed. The average net pressure in pounds is 324.3 which is nearly 16 lb. in excess of the contract requirements. The average efficiency for the period above is 72.90 per cent, which is nearly 2 per cent in excess of the efficiency guaranteed.

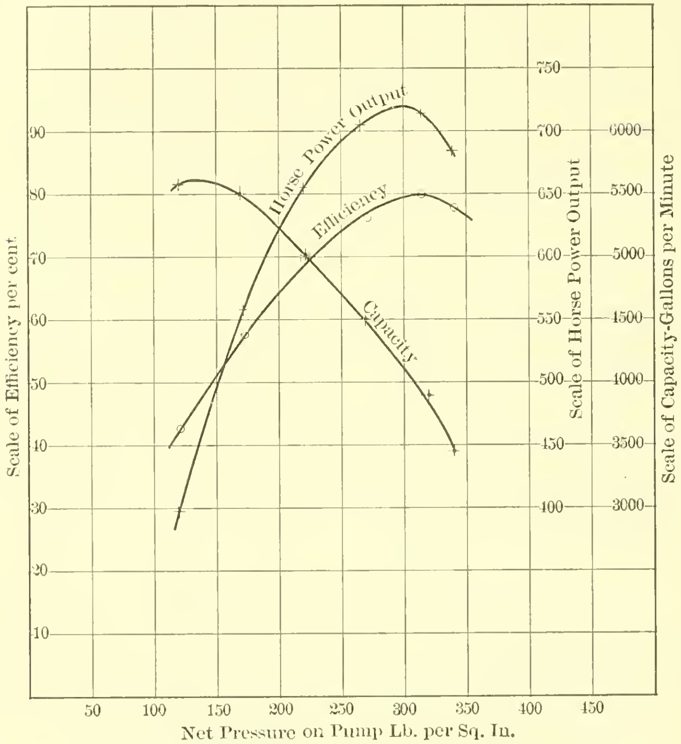

Fig. 7 Characteristic Curves of the Pump for Varying Discharge-Pressures

69 The average capacity for the entire test is 17,867 gal. which was obtained with an average speed of 753.6 r.p.m.

70 Immediately after the completion of the endurance test of 24 hours' duration, each pump was tested when operating alone for a period sufficiently long to obtain 12 to 15 readings after they had

become practically uniform. These tests gave in every case an efficiency several per cent greater than that obtained when the pumps were all discharging into the same main.

CONCLUSIONS

71 It appears from the endurance test in each station that the capacity, efficiency and pressure exceeded the contract requirements by a large margin, and that during the endurance test no mechanical or electrical defects were observed. During the test of the South Street Station one of the pumps was stopped for half an hour to repair the motor insulation, while during the test of the Gansevoort Station no stop of any kind was made. The bearings in both stations were in perfect condition at the end of the test and the temperature of the motors not sufficiently high to interfere with the continuous operation for a longer period. Apparently the endurance test could have been continued indefinitely without injuriously overworking or overloading the pumps and motors.

72 The specifications call for pumping sea water, which most authorities consider to be approximately 2.5 per cent heavier than fresh water. The effect of substituting sea water for fresh water would, for the same horse-power delivered by the motor, have been to reduce the capacity of the pump by about 2½ per cent without sensibly affecting the efficiency. Because of the large capacity over contract requirements shown by each pump, this amount does not materially affect the results.

RESULTS OF TESTS

73 The data and results of the tests at the two stations are given concisely in the following tables. The efficiency is given as computed for each hour, and shows a slight variation which probably can be accounted for by changes in the amount of water leaking past the balancing piston. The individual pump test at the South Street Station shows a variation in efficiency 70 per cent to 77 per cent and at the Gansevoort Station from 76 per cent to 79 per cent. This variation may have been due to the structure of the pumps but in my opinion is more probably due to variable leakage past the balancing piston or through the relief valves.

74 Pump No. 6 at the Gansevoort Station was tested with varying openings of the valve in the discharge pipe. The results are shown in Table No. 6 and also in Fig. 7.

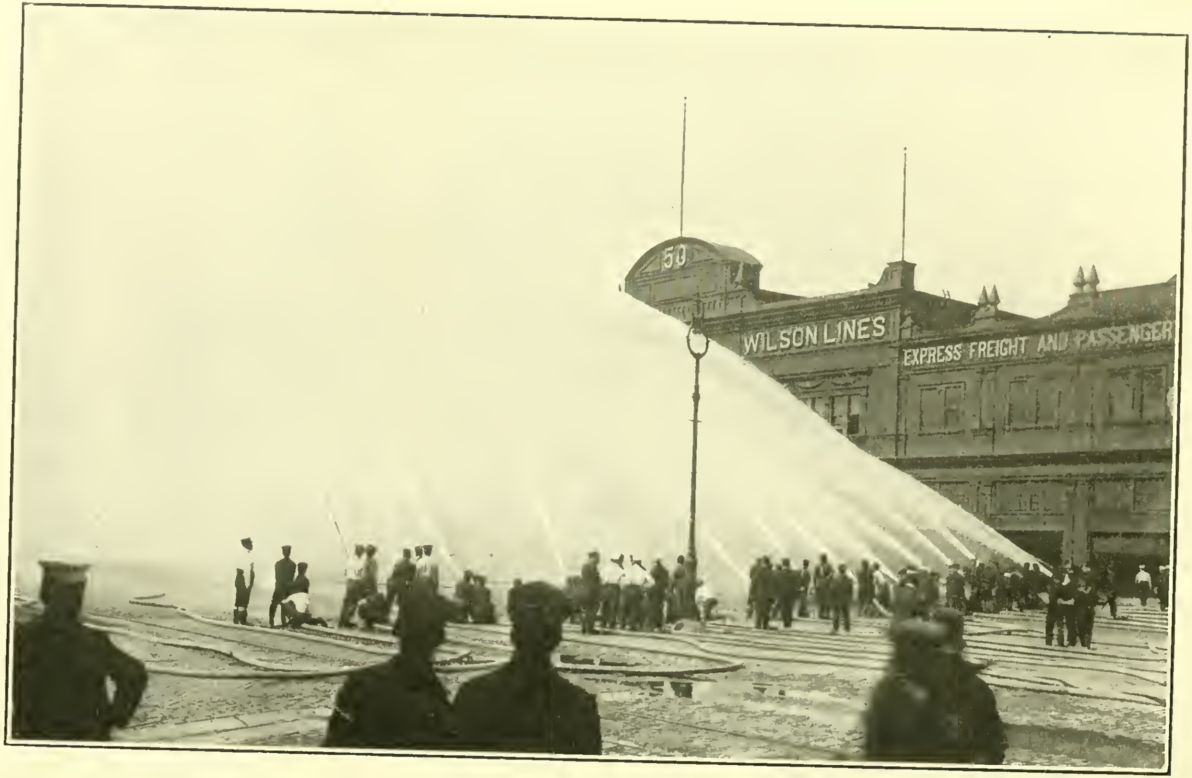

FIG. 8 VIEW SHOWING TEST OF FIRE SYSTEM

TABLE 5 TEST OF INDIVIDUAL PUMPS

Oliver and South Street Station, September 3, 1908

Time	No. of pump	Gal. per min.	Pressure delivery	Lb. per sq. in.		h.p. output	Efficiency of pump
				Inj.	Net		
12:58– 1:14	1	3372	344.4	29.3	315.1	620	74.6
1:22– 1:37	2	3809	336.0	27.9	308.1	683	70.1
1:43– 1:58	3	3495	334.0	28.7	305.3	623	73.2
2:03– 2:18	4	3705	334.5	27.8	306.7	662	76.0
2:24– 2:38	6	3740.7	344.5	28.8	315.7	689	77.0

Immediately following the 24-hr. test for capacity.

TABLE 6 TEST OF INDIVIDUAL PUMPS

Gansevoort and West Street Stations, September 6, 1908

Time	No. of pump	Elect. h.p. input	Gal. per min. Hg. Col.	Pressure delivery	Lb. per inj.	Sq. in. Net	h.p. output	Efficiency of pump
10:05–10:31	1	916	3800	356.8	35.4	321.4	711	77.6
10:36–10:51	2	877	3800	350.8	35.1	315.7	700	70.8
10:54–11:12	3	920.5	3820	350.4	34.1	316.3	703	78.0
11:17–11:30	4	892	3751.4	352.5	35.6	316.9	695	77.7
11:37–11:53	6	899	3880	350.9	35.2	315.7	714	79.4
11:55–12:03	6	880.3	3457	376.1	36.0	340.1	686	77.9
12:03–12:07	6	929	4500	304.4	34.6	269.8	708	76.1
12:09–12:13	6	946	5070	255.6	33.6	222.0	654	69.4
12:24–12:28	6	952	5500	207.4	33.2	174.2	559	58.7
12:32–12:36	6	927	5588	155.2	33.2	122.0	397	42.8

Immediately following the 24-hr. test for capacity.

PRACTICAL RESULTS FROM THE NEW SYSTEM

75 The high-pressure fire system in New York, which was put officially into service on July 6, 1908, has been successfully operated at many fires, but it had a crucial test on January 7, 8 and 9, 1909, when it was brought into service for five simultaneous fires, three of them of more than the usual extent and activity, and one particularly so. Information upon the results attained with the system and the amount of water consumed was given by Chief Engineer I. M. de Varona and published in the Engineering News of Feburary 11, 1909.

76 The fires occurred at Hudson and Franklin Streets, Hester Street and the Bowery, Houston Street and Broadway, Sixth Avenue and 17th Street, and Houston Street and the Bowery. The situation became so dangerous that every engine south of 37th Street, or 40 engines, were summoned, as well as a force consisting of 12

battalion chiefs and more than 600 men, but there was no need to use a single one of the engines.

77 As the violence of the fires increased, additional pumps were brought into service, so that at one time four pumps and motors were in commission at the South Street Station and three pumps at the Gansevoort Street Station, delivering 35,500 gal. per min. against an average pressure of 225 lb. at the pumps and 205 lb. at the hydrants. During the operation of the pumps 14,095,000 gal. were pumped as recorded by the meters, and the current used was 81,450 kw-hr., the cost of which was $1222.

TABLE 7 SPECIFIED CHEMICAL ANALYSIS FOR PUMP MATERIALS

	Nickel steel	Medium steel	Steel forging	Steel casting
Parts of 1 per cent				
Phosphorus not to exceed	0.04	0.10	0.04	0.05
Sulphur not to exceed	0.04		0.04	0.05
Tensile strength at rupture, pounds	100,000	650,000	75,000	65,000
Tensile strength at elastic limit, pounds	65,000	32,500	38,000	32,000
Per cent elongation in 8 in	2	22		
Per cent elongation in 2 in	22		22	18
Contraction of area per cent	32		32	24
Carbon not less than	20 parts of 1%			
Nickel percentage	21 to 24			

Note.—The high-pressure system was designed by I. M. de Varona, Chief Engineer of the Department of Water Supply, Gas and Electricity of New York. It was also constructed under his supervision. The construction of the electrical machinery was supervised by Prof. Geo. F. Sever as Consulting Engineer. The details of construction were in charge of Thomas J. Bannon, John P. Reynolds and Henry B. Machon, assistant engineers of the department. The machinery of each station was designed and erected by the Allis-Chalmers Co. of Milwaukee.

DISCUSSION

SMALL STEAM TURBINES

By Geo. A. Orrok, Published in The Journal for May

ABSTRACT OF PAPER

The subject of small steam turbines is dealt with from the standpoint of the designing and operating engineer. The various types of turbines now on the market are illustrated by means of sections showing their construction and photographs of the completed machine. A number of steam consumption curves are used to demonstrate the economy that may be expected from the machines in certain situations. The author also describes the details of the turbines, together with some operating conditions.

DISCUSSION AT THE WASHINGTON MEETING

Charles B. Rearick. Small turbines have become popular in large power-house work for driving auxiliaries, and we are furnishing a large number where electric motors and engines of the reciprocating type were formerly used. They are being used extensively for the smallest units in hot-well service for surface condensers, the turbine driving a centrifugal pump which carries the condensed water away from the condenser; supplanting in these cases the usual reciprocating pump. They are more efficient than the reciprocating pump, they take less space, there are fewer parts to maintain, and the service seems to be very popular. They have also proved their worth in larger installations for driving boiler-feed pumps of the multistage turbine type.

2 Some of the newest work taken up by turbine drive is for circulating pumps for surface and jet condenser work. We have a representative lot of such installations using turbines from 50-h.p. to 250-h.p., operating such pumps under low heads and at speeds as low as 600 r.p.m., direct-coupled to the rotor shaft of the turbines.

The paper on Small Steam Turbines was discussed both at the Washington meeting, May 4-7, and at the Boston meeting, June 11, 1909.

3 The question of economy is not touched upon to any great extent in Mr. Orrok's paper, except to give some curves which cover only one condition of service in most cases and cannot very fairly be compared for the different makes. High economy in small turbine units is in many instances of minor importance. Reliability of service is most important of all. Under the very low speeds for driving circulating pumps and similar pump work the economy cannot be especially good; but in nearly all these large power plants the exhaust steam is all utilized in feed-water heaters, and approximately 80 per cent of the heat is returned to the boilers.

4 There is only one class of service in which high economy is absolutely necessary, and that is, when the unit becomes the prime mover or the main unit for a plant. In that case the turbine, both condensing and non-condensing, compares well with the engine; for such work is usually driving dynamos and other high-speed apparatus and the speed can be chosen for the best economy.

5 In Par. 14 I wish to make a correction. The Kerr Turbine Company build also a 30-in. size, and their present patterns are suitable for powers as high as from 600-h.p. to 700-h.p. under proper speed conditions.

W. D. Forbes. Mr. Francis B. Stevens of Hoboken, who died a year ago in his ninety-fifth year, seeing in my shop some small Pelton water wheels, told me that in 1854 he had seen a steam turbine in a candy establishment in New York, which ran 1200 revolutions for some twelve years, with little or no attention. It drove a small fan. Mr. Stevens described the machine as practically the same as a Pelton water wheel, except that the bucket was cut in two, each half being placed on a separate disc, and the steam was led to these two buckets by a "splitter" between them, which of course was stationary. Each bucket was made fast to the disc, which was of course keyed to the shaft.

2 What seems strange to me is, if steam turbines are such excellent things and have been known so long, that they are not more generally used.

R. H. Rice. Mr. Orrok has rendered a valuable service to the Society in describing the construction of the various small steam turbines now on the market and in bringing together the economical results to be expected from such machines under proper conditions.

2 It is interesting to note that all the turbines described are of

the "impulse" or "action" type. The "reaction" turbines are not suitable for small turbine work on account of the complication and expense of their bucket systems, and this fact leads to the conclusion that the great flexibility of the impulse type will render it the ultimate type, superseding the reaction machines entirely for all classes of service. Some prominent builders of reaction turbines abroad are already using either one or two impulse stages at the high-pressure end of the turbine in combination with a reaction section at the low-pressure end; while one builder, who has already passed through this stage of development, has abandoned the reaction turbine altogether in favor of a pure impulse design.

3 The flexibility of impulse turbines is shown by the great range of capacity of the Curtis turbine, which is built in sizes ranging from 5 kw. to 14,000 kw.

4 The author describes the construction of seven different turbines, which may be divided into four classes according to the method of using steam, as follows:

a Single-stage, expanding nozzle, one bucket row, one velocity extraction: De Laval.
b Multistage, conveying nozzle, one bucket row per stage, one velocity extraction per stage: Kerr.
c Single-stage, expanding nozzle, one bucket row, multiple-velocity extraction: Terry, Sturtevant, Bliss, Dake.
d Single or multistage (depending on capacity), two to three bucket rows, multiple velocity extraction but only one per bucket row: Curtis.

5 The value of these various methods of using steam is clearly set forth in the curves presented by the author (Fig. 25 to Fig. 30), giving the water (steam) consumption of the various turbines in Classes *b*, *c* and *d*. In the diagram in Fig. 1 all these curves are drawn to the same scale so that they may be readily compared.

6 It will be seen that with one exception, a very small machine, which suffers somewhat from this fact, the water-rates of all the turbines in Classes *b* and *c* fall rather closely together, while Class *d*, even with a 50-h.p. machine, shows considerably better results. This is much more marked in the case of the 200-h.p. machine. Class *b* is represented by an eight-stage machine of 150-h.p. and shows slightly better results than the machines of Class *c*, particularly at light loads. This result is insignificant as compared with the complication of the large number of wheels, diaphragms, packings, and length of machine,

and this complication is therefore apparently not justified. The reason such multistage machines do not give better water rates is due to a considerable extent to the high frictional losses caused by rotating wheels in a dense atmosphere of steam at comparatively high pressure.

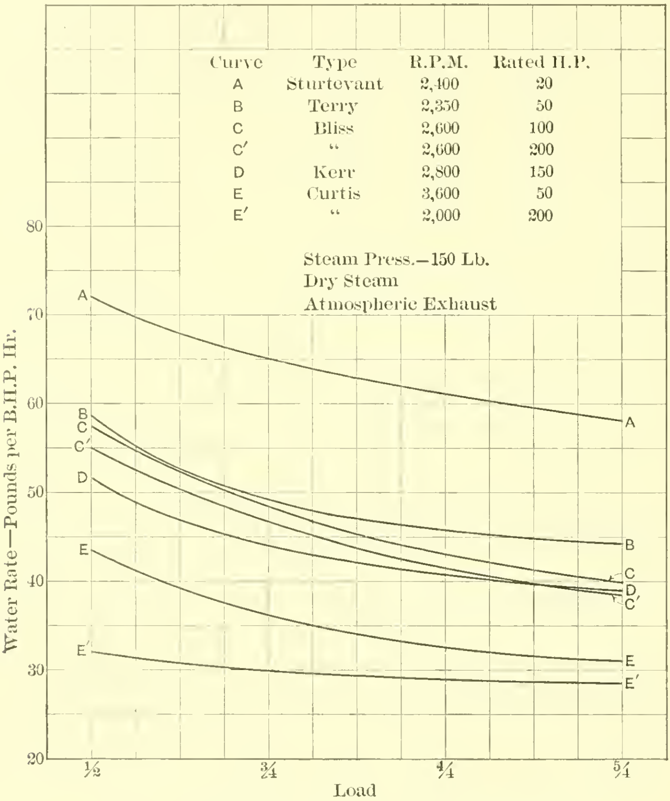

Fig. 1 Economy Curves of Small Turbines

7 The turbines of Class *c* labor under two disadvantages, due to using the steam repeatedly in the same buckets; either (as in the case of the Terry turbine) the steam has to be turned at high velocity through an angle of 180 deg. in the return chambers, or it has to be used in buckets which have in general the wrong angle of entrance; for it is easy to see that if the bucket angle is correct for receiving the jet at its highest speed, it cannot be correct when the jet has considerably slowed down.

8 The general principle employed in these turbines was used first by Professors Riedler and Stumpf in the years 1902–1903, and a number of these machines were built and put into service. The company which exploited them, however, abandoned the principle about the latter year and since then has built under a Curtis license, this step having been taken by reason of the superior economies obtainable by the Curtis construction, which the paper seems fully to confirm.

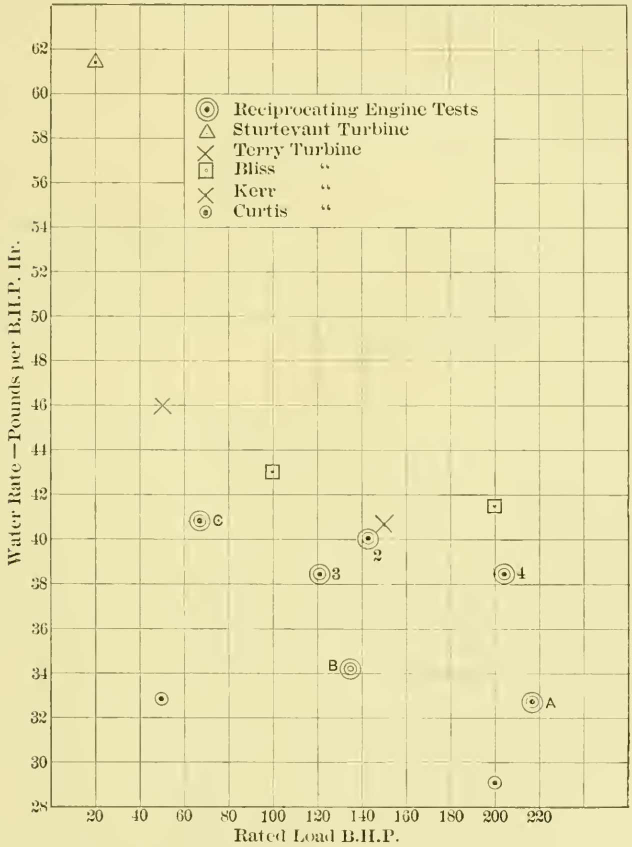

Fig. 2 Comparison of Economy of Reciprocating Engines and Turbines

9 At the Detroit meeting, June 1908, Messrs. Dean and Wood presented a paper giving results of tests on high-speed engines of sizes comparable with the turbine figures given by Mr. Orrok. Fig. 2

shows the results compared with the full-load water rates given by the author.

10 Messrs. Dean and Wood tested engines which had been in service for some time and many of which had evidently seriously deteriorated in efficiency due to wear and leakage. Mr. Orrok confirms the statement made by the writer, that the turbine does not fall off in efficiency after similar length of service and in further confirmation of this is the test on a 75-kw. Curtis turbine made by Professor Carpenter.

11 This fact has also been established by many tests made by the writer on turbines which have been in use for considerable lengths of time, and is subject only to the qualification that when steel bucket constructions are used, as in all the turbines described except the Curtis, wear may be expected under certain conditions of wet steam and light loads which will increase steam consumption after a very moderate length of service. The use of bronze buckets of the proper composition to resist this deterioration is therefore essential to secure the best results under all conditions.

Prof. R. C. Carpenter. During the past year I have given considerable study to the results from the use of small turbines, arriving at practically the conclusion of the author (Par. 33), that the field of the small turbine is somewhat narrow as compared with the high-speed steam engine. This conclusion applies to small turbines running non-condensing, however; when large turbines are operated condensing the economy is very high, and I think the results will usually be superior to that obtained with piston engines.

2 On testing one turbine, which I think had been in use for three years, I was pleased to find that my results practically agreed with those obtained when the turbine was first installed. This seems to indicate that so far as that turbine is concerned, there was no deterioration from use. The general results which I obtained in the economy tests were substantially those shown on these curves, and indicate that the economy is perhaps not quite as good compared with the piston engine; the advantages of the small steam turbine must therefore be other than simply that of economy. The results of the tests of this machine are shown in the table.

3 I have recently had an opportunity of getting figures from a small turbine operated with a high degree of superheat and running non-condensing. The results of that test were satisfactory in many ways: 350 deg. superheat seemed to have about the same effect as 18

in. of vacuum, and a machine having a water-rate given as approximately 50 lb. per b.h.p. went down to about 22 lb. per b.h.p. The small steam turbine has special advantages for many kinds of work where a high rotative speed and small torque are desirable; for those kinds of work I believe it will ultimately supersede the small piston engine.

4 Mr. Rice made the statement that he believes the reaction turbine will drop out of use; but I think he is looking at the question from a prejudiced standpoint. Charles Algernon Parsons, I find, has the opposite view. His notion is that the reaction turbine will replace the impulse turbine for large work. I think there is no question about the advantages of the impulse turbine for small work, but I do not believe the reaction turbine will drop out for large powers when a high vacuum is obtainable.

TEST OF CURTIS TURBINE, 75-KW. CAPACITY, OPERATED NON-CONDENSING
October 13, 1908

Test No.	1	2	3
Electric load, kilowatts	57.7	22.6	35.1
Pressure at throttle, pounds gage	121.6	95.0	93.3
Pressure at nozzle, pounds gage	108.4	86.0	82.6
Back pressure, pounds gage	0.24	0.07	–0.25
Barometer reading, inches	30.0	30.0	30.0
Total water to boiler, pounds	14971	1986.5	7454
Wet steam to turbine, pounds	14121	1833	6973
Quality of steam, per cent	98.3	99.0	99.0
Dry steam to turbine, pounds	13881	1815	6903
Dry steam to turbine per hour, pounds	3085	1815	2301
Dry steam to turbine per kw-hr., pounds	53.5	80.4	65.6
Equivalent per i. h.p. (provided 1 kw. = 1.6 i.h.p.)	33.5	50.3	41.0

Note—The pressure at the throttle is practically the same as at the boiler, which stood about 80 ft. away.

H. Y. Haden. A field for small turbines not touched by this excellent paper is that of installations where exhaust steam can be utilized to advantage. There is an installation in Pittsburg of a 150-h.p. turbine connected to centrifugal pumps, which operates under very unusual conditions. Primarily, it takes the exhaust of reciprocating pumps, without any regenerator, and develops the full power when exhausting into a vacuum of 25 in., but it is also capable of automatically taking high-pressure steam at 125-lb. pressure, should the supply of exhaust steam fluctuate too much or be entirely cut off. The same turbine also operates taking steam at 125-lb. pressure and exhausting into the atmosphere, and it had further to be guaranteed by the manufacturers to take high-pressure steam at 65-lb. pressure when exhausting freely. I believe the above four conditions could not be met by any reciprocating engine. Of course maximum economy will not be attained under each, but it is attained under two: that of exhaust-pressure condensing and high-pressure condensing.

2 The turbine is of the De Laval type, which is particularly adaptable for changing steam conditions, and is the only machine in which any desired plan of operation can be attained by simply changing nozzle ratios, without any change in the angle of the bucket or velocity of the pump, and without sacrificing either capacity or efficiency. I believe there is a large field for turbines operating under conditions such as the foregoing, whether connected to generators or centrifugal pumps—a field where one can depend upon a unit irrespective of the supply of exhaust steam and without a regenerator or other expensive auxiliary.

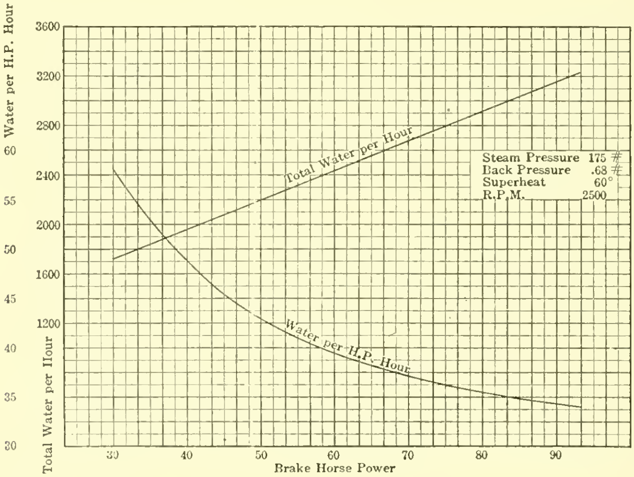

Fig. 1 Curves of 90 h. p. and 50 h. p. Terry Turbines

Fred. D. Herbert. Mr. Orrok did not mention tests made on the Terry turbine at the New York Edison Company's plant some years ago, in which the steam consumption is much below that shown in the Terry curve (Fig. 25); possibly because of his preference for tests made outside the builder's works. The accompanying curve and tables show the water rates of 90 h.p., 50 h.p., 25 h.p. and 12 h.p. Terry turbine respectively.

TABLE 1 TESTS OF A 25-H.P. TERRY TURBINE

Test No.	Steam Pres.	Back Pres.	Quality or Superheat	Speed r.p.m.	Load b.h.p.	Per Cent of Rating	Total Water per hr.	Water per h.p. hr.
			Degrees					
1	90	0	62.50	2500	25.52	102.0	1068	41.85
5	90	0	71.70	2500	18.60	74.5	851	45.72
2	90	0	82.42	2500	12.39	49.5	680.5	54.93
10	90	0	50.00	2100	24.29	97.2	1068	44.00
11	90	0	60.26	2100	15.816	63.4	808.25	51.09
6	90	0	45.60	1800	22.90	92.0	1077.25	47.10
7	90	0	79.86	1800	10.21	40.8	638.58	62.54
9	90	0	44.70	1800	15.59	62.4	807	51.76

TABLE 2 TESTS OF A 12-H.P. TERRY TURBINE

Test No.	Steam Pres.	Back Pres.	Quality or Superheat	Speed r.p.m.	Load b.h.p.	Per Cent of Rating	Total Water per hr.	Water per h. p. hr.
			Degrees					
1	136.5	0	58	2501	13.65	113.6	577.3	42.0
2	136.8	0	15	2513	12.08	100.7	547.2	45.3
3	128.5	0	12	2490	11.70	95.6	545.2	46.6
4	130.9	0	0	2501	7.23	60.2	421.5	58.3

2 Regarding the statement that turbines are built of the single stage only, the Terry Company has in operation and under construction several two-stage condensing turbines, the largest of which is 600-h.p. and the smallest about 125-h.p. Because of the successful results obtained, the builders claim that the turbine is superior to the reciprocating engine as an operating proposition, and in none of these turbines now running has a bucket been replaced. No one could make a living on the repairs to small steam turbines, which is one of the disadvantages from the selling point.

W. E. Snyder. Almost all the emphasis has been laid on steam economy. Another point which should receive careful consideration is the lower cost of maintenance, particularly where turbines are used for boiler feed, replacing the direct-acting boiler-feed pumps ordinarily used; for pumping circulating water to condensers; or for driving centrifugal pumps pumping water at comparatively low heads. In all this work the turbine replaces direct acting pumps which are very expensive to operate, not only from the standpoint of steam-consumption, but from the cost of supplies, such as cylinder oil, packing and pump valves. I have in mind one central condensing plant served by a direct-acting pump where the costs are from $75 to $100 a month for packing, cylinder oil and valves. A similar condensing plant served by a small turbine involved practically no expense for these supplies.

2 The first question, three or four years ago, before our company had installed any of these machines, was not a question of steam economy so much as of reliability of operation. If we put in a turbine to pump water for a central condensing plant, into which exhaust a large number of steam engines of various kinds and used for varied service, would the turbine break down, just when it was most needed? For the purpose of investigating this point I went to a plant which had a small unit in operation driving a generator and which had been in use for about four years. The gears showed no appreciable wear, and there had been practically no shut downs.

3 The result of that investigation was the adoption of turbines in central condensing plants in a number of works with which I have to do, and also later for boiler feed and for pumping water under low heads; and they have proved generally reliable regardless of make. This is also true in regard to small turbine air-compressor units for the cupola, etc., in steel works.

4 I think it is, therefore, in the displacement of the direct-acting pump, always expensive to operate, apart from steam consumption, that the small turbine will find its greatest field of usefulness. In the 39th Street Edison Station in New York, the turbine-driven boiler-feed pumps have been continuously operating for months, running almost automatically, and requiring practically no attention or supplies. Steam economies are of course important, yet in large plants where all of the large units are condensing, the steam from the auxiliaries is needed to heat the feed-water, and a few per cent more or less in steam consumption of turbine auxiliaries does not materially change the total economy of the plant.

5 Other advantages in favor of the small turbine as compared to direct-acting pumps, are the small space required and the fact that they can always be kept clean and present a good appearance. Direct-acting pumps are usually very difficult to keep in presentable condition on account of water leakage and of the excessive use of lubricants. The turbine and pump are entirely enclosed, the case can be wiped very conveniently, and it presents nothing of the unsightly appearance which is so often characteristic of the direct-acting pump.

William T. Donnelly expressed the opinion (in response to a question by Mr. Forbes as to why turbines did not come into more general use at an earlier date) that we do not thoroughly appreciate the important bearing which the interchange of knowledge has in the development of apparatus such as a turbine. The steam turbine has been brought to the attention of people and results have been accomplished with it in recent years because of the general interchange of knowledge and the discussion of engineers on the subject. In the early days of circular sawmills, many of them were driven by 3team turbines. When they were finally replaced by reciprocating engines, there was considerable objection on the score of steam consumption.

2 The development of the modern steam turbine was brought about substantially by the individual work of one man, Mr. Parsons, in persisting in his efforts to develop a turbine which would give practical results. No attention was paid to his efforts for a period of eight or ten years; when he accomplished practical results, and the knowledge was distributed through the engineering societies in this country, we commenced to look into it, and the energy of British engineers in following up the work of Mr. Parsons is the reason why the steam turbine has come to the front. They forced our attention to the marine turbine by building a small boat and accomplishing results. The same was true in regard to the application of steam turbines in driving electric units. I think we can credit the great development of the steam turbine in recent years largely to discussions of technical societies by which the attention of engineers has been brought to it.

F. H. Ball. The conclusions of the author regarding the future of the small steam turbine may fairly be questioned. On the score of efficiency the showing made by the several types, even when tested by the parties interested in their success, is very poor. From these test figures, it appears that the best performance ranges from about 30 lb. per h.p. per hr. to nearly 70 lb.

2 It must be noted also that very high steam pressure is generally used, and in some cases superheat. Under these conditions any good reciprocating engine, even of the single-valve type, run as a non-condensing compound, would easily develop power on 20 lb. or less: the user of one of the non-condensing turbines described must therefore expect to increase his coal bill from 50 to 200 per cent over a single-valve non-condensing compound engine having the simplest possible form of valve gear.

3 Moreover, the speed of these turbines, from 2000 to 3600 r.p.m., will generally be considered objectionably high. Buyers of electric motors generally prefer motors of moderate speed, even at the extra cost, and generally speeds above 1000 r.p.m., even for motors as small

as 10 h.p., are considered objectionable. This same objection must inevitably be urged against speeds of 2000 to 3600 for engines of considerable power.

Chas. A. Howard spoke in reply to the same question, calling attention to the fact that as it is only in the last few years that there has been high-speed machinery for turbines to drive, engineers have been rather afraid of the use of reducing-gearing.

2 As far as a comparison of the merits of different turbines goes, it must be remembered that the economy is affected by the bucket speed even more than by steam pressure. In all of these tests the bucket speeds are different, and any attempt to make a comparison of the steam economy, as in the diagram by Mr. Rice, would thus lead only to an erroneous view. While his curves show in general what may be expected from turbines of this size, no correct comparisons can be drawn between individual machines.

3 It is to be noted also that some of these tests are made by the manufacturers, and naturally under the most favorable conditions possible, while others are made by outside parties with the conditions as they happened to be. This fact, together with the difference in bucket speeds, makes an attempted comparison very deceptive.

4 In comparing the steam consumption of the small turbines with what has been obtained by reciprocating engines under similar conditions, attention is called to the paper presented at the spring 1908 meeting of the Society by Messrs. F. W. Dean and A. C. Wood (Proceedings, June 1908). This paper gives results of tests on several makes of reciprocating engines in which the steam consumption per brake-h.p. hour runs from 39 to 42 lb., which is no better and in many cases not as good as the performance of the turbines.

DISCUSSION AT BOSTON MEETING

Dr. L. C. Loewenstein[1] presented a number of lantern slides showing various types of turbines and discussed the relative advantages of each type. For constructive reasons the peripheral speed of the buckets of the DeLaval turbine cannot be made high enough to obtain the highest efficiency. To reduce the peripheral speed of the turbine and still use the energy of the steam economically, the steam should pass through the buckets a number of times, each row abstracting only a part of the energy.

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[1] General Electric Co., West Lynn, Mass.

2 The Kerr turbine is based on the Rateau principle. In an 8-stage Kerr turbine, operating non-condensing with 175-lb. initial pressure, in each stage the pressure would be as follows:

1st stage	144	lb. absolute	
2d “	108	“	“
3d “	80	“	“
4th “	58	“	“
5th “	42	“	“
6th “	30	“	“
7th “	21	“	“
8th “	15	“	“

The turbine casing is thus subjected to widely varying pressures. The rotation losses of the eight rotating wheels and buckets may be determined by Stodola's formula

$$\text{Loss in horsepower} = \left(\frac{u}{100}\right)^3 y\,[0.072\ D^{2.5} - 0.6L^{1.25}]$$

in which y is the density of the steam in which the wheel rotates, D is the diameter of the disc in inches, L is the height of the buckets in inches and u is the peripheral velocity in feet per second. The large number of wheels and buckets, besides making a constructive disadvantage, increases the length of the steam path and causes large steam friction losses.

3 The principle involved in the Terry, Sturtevant, Bliss and Dake turbines is that employed first in the Riedler-Stumpf type, and consists in passing the steam through the same buckets a number of times. The disadvantages of this type are, first, the steam must turn through 180 deg. to re-enter the buckets, causing a high friction loss; secondly, the reversing chambers are not constructed to guide the steam correctly into the buckets; thirdly, in some machines the steam re-enters on the same side as it left the buckets, so that if the angles are correct for the steam leaving the buckets they cannot be correct for the re-entering steam. On account of the high water-rate, the principle was abandoned for the large sizes of machines. It is still used in smaller sizes chiefly because of lower cost of construction.

4 The fourth type discussed by Dr. Loewenstein was the Curtis turbine, the illustrations showing a small size of one stage and a larger size of two stages. Curves of steam consumption were pre-

sented to show the comparative water rates of the various classes of the Curtis type. Among the advantages cited for the Curtis turbine were: high velocity of steam through the several rows of buckets; the steam impinges at the proper angle on each row of buckets; buckets of a special extruded metal are used to avoid erosion by wet steam; and an emergency governor prevents excessive speeds.

W. J. A. London.[1] With reference to Richard H. Rice's comparison at Washington of Fig. 25 and Fig. 28, showing the steam consumption of the Terry turbine and that of the Curtis turbine, if the curve of the Curtis turbine be produced and the peripheral speed of the two types be made the same, the curve of the Terry turbine will cross that of the Curtis type at about 1950 r.p.m. See Fig. 1. There is therefore not much room for discussion of the difference of efficiency of the two types. Moreover, with a large turbine an increase of a pound on the steam consumption would increase the cost bill from $2000 to $4000 a year, but with a small turbine it would mean an increase of only from $10 to $25 a year, which would be offset by the difference in first cost.

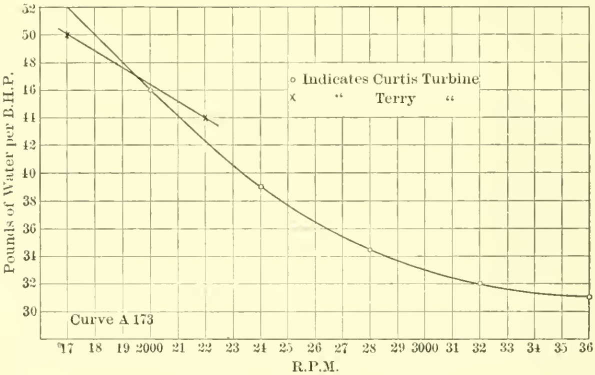

Fig. 1. Comparison of Tests in Fig. 25 and Fig. 28 Reduced to the Same Wheel Velocity.

2 The greatest value of the paper lies in the fact that, better than a salesman, it shows to men having reciprocating engines, the great simplicity of construction of the turbine. Men familiar with reciprocating engines know what to do in case of breakdown, but with a

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[1] Terry Steam Turbine Co., Hartford, Conn.

turbine a failure means a shutdown for several days. In a few years, however, every engineer will thoroughly understand the construction of a steam turbine and will be able to make his own repairs. Another fact which hindered the more frequent use of the steam turbine was that generators, pumps, blowers and other machines had to be designed specially for operation with turbines. That this is now being done is an acknowledgment that the steam turbine is here to stay.

Chas. B. Rearick. The fact that the small steam turbine has obtained a footing is evidenced by the number of installations. It is now used for a variety of pumping service, such as driving hot-well pumps and circulating pumps for condensers; multi-stage pumps for high-pressure work, including boiler feed service; water-works pumping service where maximum economies, obtained only with fly-wheel types of reciprocating pumps of expensive design, are not essential; and for house-service pumps in buildings.

2 The matter of speed is often a compromise, as the pump speeds are not always ideal for the turbine. Especially is this true for circulating work where the heads are often only 15 or 20 ft. and the delivery 20,000 gal. or more per min. It may be necessary to sacrifice some efficiency of the pump in order to run at a speed suited to the turbine. In such instances all the exhaust steam may be used to advantage in heating feed water, while the low cost of operation and the saving in oil and supplies will overcome the cost of increased steam consumption.

3 The steam turbine has made very rapid strides in the driving of blowers for forced draught and such work in large power plants. Many engineers are adopting turbines for driving practically all auxiliaries in large power plants. The question of efficiency is secondary to a great extent for the reasons cited above. It does not matter if the steam consumption of the auxiliaries runs up to 70 lb. per horsepower per hour as a large part of the heat in the exhaust is returned through the heaters. When efficiency is of importance, as in isolated dynamo work, the speeds are usually such as to give results quite as good as those of the reciprocating engine, and in many cases better. The turbine has demonstrated its ability to give economical results in all cases where the speeds are favorable.

4 Regarding the rating of turbines, there is only one point of maximum efficiency of any design, so far as I know, and that is its maximum load. It is very similar to a gas engine in that respect.

If we want maximum efficiency the turbine must carry its maximum load. That can be brought about in some cases by the nozzle system of design in which better economy is obtained at light loads by shutting off nozzles. But where this is done by hand regulation there is always danger of the load coming on without notice or without the engineer having opened any of the hand adjustments. Turbines should therefore be designed to eliminate hand regulation, and to accomplish this some builders provide for automatic operation of these valves. While this is successful within a limited degree, these valves may become leaky in service, and when once leaky the control of the turbine is beyond the operator, which may result in over-speeding to a bursting point in case the load is suddenly thrown off.

5 It follows that the number of controlling valves should be reduced to a minimum. If there is only one valve to control in a machine there is but one valve to look after and to keep tight. Few operators of turbines appreciate how serious the leakage of the controlling valve is to the proper governing of the turbine, especially on very light loads or no load. On the other hand, if turbines are kept well loaded these leaky valves are not noticed and as a result steam consumption is increased through their use rather than diminished, unless all the valves are wide open and the turbine is working up to its full capacity. The turbine which eliminates these dangers, it would seem, is the better machine, and in small units the difference in economy is entirely outweighed by the complications and dangers above cited.

F. B. Dowst. The B. F. Sturtevant Company have for years built reciprocating engines—single engines, multiple-single engines, and multistage engines. Later we built direct-current and alternating-current motors. We first came into touch with the steam turbine principle in 1883 when our attention was first called to the Wise steam motor. This motor was an impulse wheel, with four jets, I think, the steam impinging on buckets, no endeavor being made to expand the steam in nozzles. One of our engineers left us at that time to exploit the Wise steam motor. He returned after a year's sad experience in connection with the amount of steam that would flow through a small opening.

2 Our next experience was with the Dow steam motor. Mr. Dow came to us early in the nineties, I think it was, backed by Mr. Chisholm of the Chisholm Shovel Works of Cleveland, O. This turbine had previously been developed and used successfully to drive

the flywheel in the Howell torpedo. Associated with Mr. Dow was Mr. Howard, for some time connected with the Fore River Ship and Engine Company, as it was then called. The Dow turbine was built in the Sturtevant works and was really a meritorious machine. It was what might be called an inward-flow reaction turbine. A motor of bronze was built and the method which Mr. Dow developed is now used in balancing our rotors.

3 A little later, during the development of the Curtis turbine, a representative of Mr. Curtis came to us for journals for high-speed work. He had trouble in finding a journal box capable of withstanding the high speed of his rotor shaft. A box that we used was very successful in solving the problem. We knew there was a somewhat limited field for high-speed motors for use with our fans, however, and were not quite ready to take up the Curtis turbine commercially.

4 Later we built a turbine for a man from California; I think his name was Hewson. We never reached the testing stage, however, as the machine was burned in our fire of 1901 and Mr. Hewson disappeared so far as we were concerned.

5 A completed Dow turbine was frequently connected with one of our No. 6 blowers. The governing device was not developed, but that was not necessary in order to connect the turbine with a fan. I believe this turbine was tested in our works, and afterwards tested at the Massachusetts Institute of Technology for water consumption, which was found to be high. I have always thought that the Dow turbine possessed great possibilities and wondered why someone did not develop it.

6 When we cleaned out Mr. Sturtevant's desk in 1890, we found over 200 patents on rotary engines, showing his natural interest in high-speed motors. Although many rotary engines have been presented to us, we never found it practicable to use any of them.

7 Experiments with a steam turbine of our own for use with our fans resulted in the turbine described as the Sturtevant turbine. Mr. Orrok's description of the rotor is substantially correct, except that he omitted the fact that in the manufacture of this part we use an open-hearth steel forging of the best quality. Among the uses of the turbine are direct connection with generators, with fans for blowing blast furnaces, and with multivane fans for work on shipboard. Four fans with geared connection, recently built for a heating system in the West, have done good work.

8 An interesting problem was recently presented when the Navy Department insisted on fans for forced draft for the new torpedo boats

where oil fuel is to be used. This of course demanded a slow-speed turbine, but we think we have worked out a satisfactory combination by effecting a compromise between the fan and the turbine element. It is interesting to recall that a few years ago the Navy Department did not consider any motive power except a reciprocating engine. Later the electric motor came into use and now many of the new ships are equipped with forced-draft fans driven by electric motors.

9 There is not the slightest doubt that the general type of turbine discussed in Mr. Orrok's paper is here to stay. Engineers like it and engine builders must get ready to furnish turbine engines.

Chas. B. Edwards.[1] We are more particularly interested in the development of the large marine turbine, but our attention has been recently directed to the smaller turbines owing to the Navy Department specifying them for blowers; there is also a possibility of their use for circulating pumps and other auxiliary machinery on board ship. The Navy Department has increased the steam allowance for turbine installations over what it was a few years ago when it was limited to 50 lb. per h.p. hour.

2 The great problem in marine installations, particularly for naval purposes, is that of weight. The navy contracts specify a certain weight of machine and if we exceed that weight we must pay for it at the rate of about $500 a ton. In considering the turbine proposition, therefore, we must look at it not only from the mechanical side but also from the standpoint of weight. One of the difficulties, of course, is that of the exhaust. The weight of piping, fittings, valves, etc., runs up rapidly and it is therefore desirable that turbine auxiliaries should be placed as close to the condenser as possible; and in order to secure economical results it is also desirable to secure a low velocity of exhaust in the pipe lines.

V. F. Holmes.[2] The DeLaval Company has recently brought out a combination high-and-low-pressure steam turbine. Many plants where condensing water is available have an excess of exhaust steam from auxiliaries and the question has arisen whether a machine could not be devised for this class of service. That would necessitate storing up energy in times of an excess of exhaust steam to carry the machine over the periods of limited exhaust steam, and would involve expense and complications. What is desirable is a machine in which both the exhaust and the live steam can be used economically without regenerators and other heat-storing devices.

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[1] Chief Engineer, Fore River Shipbuilding Co., Quincy, Mass.

[2] Power Equipment Company, Boston, Mass.

2 The DeLaval combination high-and-low-pressure turbine is built with two nozzle compartments, one for high pressure and the other for low pressure. Each compartment is furnished with nozzles having the proper ratio of expansion for the conditions under which they operate. Some of the nozzles are furnished with shut-off valves for regulation under variable conditions.

3 Two steam connections are provided, one for high-pressure steam and the other for low-pressure steam, each connection leading to its own governor valve, which in turn is operated by a separate governor. The operation is entirely automatic, the low-pressure governor being set for a speed slightly higher than that of the high-pressure governor. On the total or partial failure of the low-pressure steam supply the machine will automatically draw from the high-pressure steam supply the steam necessary to make up the deficiency. Also in case of the complete failure of the low-pressure steam supply, the machine will operate on high-pressure steam, and under this condition will give practically the same economy as a high-pressure steam turbine.

4 The combination high-and-low pressure turbine is built for conditions where continuous operation is essential and where the supply of low-pressure steam is intermittent or is apt to fail completely. The regulation when changing from one steam pressure to the other varies from 2 to 3 per cent, this being on an instantaneous change from one condition to the other, such as seldom occurs in actual service. A by-pass valve allows the admission of high-pressure steam into the low-pressure compartment, for operation under full-load conditions non-condensing. This by-pass valve is not automatic, and is simply to enable the machine to carry full load in case of failure of, or during repairs to, the condensing apparatus.

5 Both the low-pressure turbine and the combination high-and-low pressure turbine are built for steam conditions varying from 5 lb. pressure above atmosphere to 10 in. of vacuum at the steam inlet. They are also built for low vacuums for conditions where the temperature of the circulating water or existing condensers prohibits the maintenance of a high vacuum. The steam consumption of the machine varies somewhat with the sizes and operating conditions; the average machine operating with steam at atmospheric pressure and exhausting into a vacuum of 27 in. to 27½ in. will use from 28 lb. to 32 lb. of steam per b.h.p. hour.

6 The DeLaval Company is also building a high-speed, low-pressure turbine particularly adapted for direct connection to centrifugal pumps and blowers. This class of machine is built in both the low-pressure and combination high-and-low pressure types, and consists of the DeLaval wheel direct-connected to the machinery to be driven. On account of the direct connection of the wheel and the elimination of the usual DeLaval reduction the machine can be economically operated only at high speed, and for this reason is not suited to direct-current generator work, but is particularly adapted for high-speed pumping and blower work, such as power-plant auxiliaries, boiler-feed pumps, elevator pumps, etc.

J. S. Schumaker. An error has crept into these figures that I am sure was not intended. That is, the figures given for the economy of the Terry steam turbine were obtained from a turbine with nozzles designed for 100 lb. pressure. But the steam pressure used on the test was, I believe, 150 lb. One other point that may in fairness be brought out is that the Terry turbine tests as offered here were made without representatives of the Terry Steam Turbine Company being present, while in the majority of the other cases cited the tests are shop tests.

Prof. Carleton A. Read. I am interested from the fuel side of the question in the use of non-condensing turbines in small manufacturing plants of from 75-kw. to 300-kw. capacity, where there is an excess of exhaust that can be used only for feed-water heating and heating the buildings in cold weather. We all agree that it is well not to have oil in the exhaust if the condensation is to return to the boilers, but many plants have a good and cheap water supply and after using as much of their exhaust as possible still have some going to waste. Nearly all of the tests quoted are from the manufacturers and without doubt are correct for the conditions under which they were made, but data as to coal consumption under actual working conditions would be of interest to the man buying an equipment for a small plant.

Prof. Ira N. Hollis. One aspect of the subject impresses me as important. The curves of efficiency used for comparing different turbines relate particularly to the thermodynamic efficiency of the machine or the number of pounds of steam per horsepower developed. It seems to me that where a steam turbine is connected with a pump, such as one used for feeding a boiler or for circulating water in a condenser, the machine ought to be treated as a whole. From this point of view, the number of gallons of water delivered per pound of steam or per pound of coal is an important factor and should be given in every case. Naturally the pressure against which the water is pumped is another factor. Ordinary reciprocating engines driving feed pumps are very uneconomical machines. I have had experience with pumps that used 100 lb. of steam per i.h.p. or even more. However, the efficiency of the pumps as a whole for delivering water into a boiler was never worked out.

2 It may be that the steam turbine is to replace the steam engine for all purposes about a power station, particularly if the high-pressure centrifugal pump can be developed into a highly efficient machine in connection with the turbine. It seems to me, therefore that it would be useful in connection with all tests of turbines used to drive pumps, to give the combined efficiency of the machine as a whole.

Prof. Edw. F. Miller. In looking through these figures of steam economies it will be noticed that the greater the load the smaller the amount of steam per horsepower. All the turbines I have had to do with would stand considerable overload, in some cases 80 per cent. I would like to know what decides the maker in rating his turbine. Apparently the economy line runs down as the overload goes on. Why not rate the turbine higher and get better economy?

John T. Hawkins. I was a pretty old engineer when the turbine was born and consequently know little about it except what I have learned by reading and observation. I am not going to try to impart information but I wish to ask a question. It seems to be a well-known fact that with the turbine engine, the higher the load the greater the efficiency within its limits. To what is the fact due that the turbine is more efficient under high load?

Richard H. Rice. Just a few words in explanation of why the turbine water rates decrease as the load goes up and of the effect of the various governing mechanisms on this action. The impulse turbine is essentially a turbine of partial admission. In a multi-stage condensing turbine of this type the buckets in the last stage are usually designed of the right height and the nozzles of the right proportion to use the entire circumference of the wheel. In a four-stage machine, the next to the last stage will use perhaps one-half the circumference of the bucket wheel for steam admission. It could be designed to use all the circumference, but that would involve undue shortening of buckets. In the second stage there is a further shortening of the arc of steam flow, and in the first stage, a still shorter arc is used, perhaps 90 deg.

2 In non-condensing turbines, if we were to attempt to use the entire circumference of the wheel the buckets would be so small that the machine would be impracticable and inefficient. We must therefore use a short arc, decreasing the cost of the governing mechanism and making a reasonable bucket speed possible. It is evident that the bucket speed must depend on the size of the machine and that, in connection with the operating speed, it is the prime consideration in the cost of the machine. It would be a mistake to make a 25-kw. machine with the same bucket speed as a 300-kw. machine, because the former would be so large in diameter and so expensive as to be impracticable.

3 It follows that one reason why the turbine increases in economy as the load increases is that a larger circumference of bucket wheel is used; a smaller percentage of the total power is wasted and therefore efficiency increases. Therefore, if the governing mechanism works by throttling we have this condition: the steam pressure and area of the nozzle system determine the amount of steam that can be used in the turbine. In a machine with nozzles wide open, the latter must be so designed that the turbine will carry maximum load, as otherwise the turbine would shut down at maximum load. It follows that nozzles designed for full pressure at maximum load will be greatly throttled when running with light load, and consequently the efficiency will decrease. Therefore it is advisable to govern the nozzle system in such a way that nozzles can be designed for full boiler pressure. By using a larger or smaller number of nozzles, and hence a larger or smaller arc of wheel, the full economy of the nozzles is obtained and only the proper number of nozzles are open for a given load.

CHAS. H. MANNING. The diagrams confirm the opinion I had formed of the small steam turbine to the effect that it is a steam thief. But that its virtues will outclass its sins I am thoroughly convinced. Recent developments of high-speed centrifugal pumps, fans and generators open a field for the turbine in which it is sure to succeed.

2 A small practical point is that almost all of these small high-

speed machines use the ring oiler, which is in general bad practice. It has a very small contact on the shaft and any small thing will stop its running. Furthermore, the rings frequently break. If for the ordinary ring oiler a chain with a large arc of contact is substituted, preferably a window-cord chain, it will never fail and will bring up ten times as much oil as a ring oiler. While this is a small point, any machine depends more on the perfection of its detail than it does on the theory on which it is built.

C. P. CRISSEY.[1] There is one type of the small turbine to which the author has given scant space; that is, the small condensing machine. While, perhaps, the field is not so wide for this type as it is for small turbines exhausting at or above atmosphere, it cannot be ignored. Practically all marine work requires condensing prime movers, and many small stations use this type. Only one example of a condensing machine is referred to by the author, the results of tests being shown in Fig. 30. It would be a mistake to consider this curve as representative of small condensing turbines.

2 Small turbines as well as large derive great benefit in economy from high vacuum, and a vacuum of 28 in. is easily obtained on small machines of proper design. In a well-designed small turbine the vacuum shows no greater tendency to fall with the increase of load than in large machines. Why the Kerr turbine shows a loss in vacuum as the load and hence steam flow increase, we are unable to tell definitely from this paper. It will be noted that the steam is discharged from the buckets on each side of the wheels. It is therefore necessary for one-half of the total flow to pass about the wheels in order to reach the succeeding nozzles. Excessive velocities and throttling will occur in the low-pressure stages where the volumes encountered are great, unless large areas are provided for this steam. I understand that in the Kerr turbine this throttling is obviated as much as possible by providing holes in the wheels. These holes, however, increase the windage loss.

3 One of the reasons for abandoning the Riedler-Stumpf turbine in Germany was the inability of its buckets to handle large volumes of steam successfully. The same objection holds against all machines of the Riedler-Stumpf type.

4 The only small turbines having buckets capable of caring efficiently for large volumes of low-pressure steam are the De Laval and the Curtis types. The DeLaval turbine is seriously handicapped

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[1] General Electric Co., West Lynn, Mass.

by its high rotative speed, while the Curtis turbine, due to its pressure and velocity stages, is capable of moderate speeds. In order to show that the results of Fig. 30 are not typical of all small condensing turbines, I will say that Curtis condensing turbines of from 100 to 200 h.p. give economies of 18.5 to 15.5 lb. of steam per b.h.p. hour when operating with 150 lb. dry steam and 28 in. vacuum.

5 Regarding the curves of this paper, I believe they should be compared at rated speed, because the bucket angles are designed for this speed. The rated speed may be taken as the maximum stated upon the curves.

Chas. B. Burleigh presented a comparison of water-rate curves given in the paper with a view to determining the relative efficiencies of different types of turbines. As the results derived are substantially in accord with those previously given in a discussion upon the paper by Richard H. Rice at the Washington meeting, they are not here published. Originally the Curtis buckets were milled in the wheel peripheries, said Mr. Burleigh, but experience has demonstrated that where any perceptible moisture is present in the steam, steel turbine buckets will wear. The liability of operation under wet steam conditions is much more common in small steam units than with large ones, as superheaters are seldom if ever installed in small plants, pipes are seldom covered and long steam mains are usual. For this reason the use of steel buckets in the Curtis turbine was abandoned some years ago, and all turbines from the smallest to the largest are fitted with composition buckets upon which many years of use with wet steam has no appreciable effect. Mr. Burleigh continued, as follows:

2 The paper states that the Sturtevant, Bliss and Curtis machines are provided with emergency governors. It would be interesting to learn if the Terry, Dake and Kerr are not similarly equipped. I should feel it to be a serious handicap against their successful introduction.

3 In Par. 25, the author emphasizes the reliability of this type of prime mover, which to my mind is the principal justification for its existence. This is greatly enhanced by its simplicity. The only moving parts, other than the shaft, are the wheels; and, like the hydraulic turbine, omitting the bearings, in no part of the structure is moving metal brought in contact with stationary parts. Can anything more simple be conceived?

4 In Par. 22 is the statement that "in none of these machines is

clearance an important factor.'' This is characteristic of the expanding-nozzle turbine regardless of size, and is due to the fact that in this type of machine all steam expanded by the nozzles is at a pressure corresponding to the stage into which it is admitted; therefore the atmosphere surrounding the buckets is of a uniform density and there is no tendency for the admitted steam to change its course and escape into an atmosphere of less density.

5 I wish to comment on the author's implication in Par. 33, that the small turbine is less efficient than the high-speed steam engine, where he says: "The field of the small steam turbine is somewhat narrow when compared with the high-speed steam engine. The small turbine has its place, however, and with the development of a more economical machine at lower speed ranges, will have a much wider field."

6 I will readily admit that its present speed characteristics limit its field in comparison with the high-speed engine to the extent of the mechanical application of its output; but I will not admit that the present efficiency of the Curtis type in any way limits its field in comparison with the high-speed engine, nor do I think the author intended it to be so understood. But to obviate any possibility of error, I will call attention to a paper presented last June by Messrs. Dean and Wood before this Society and the discussion which followed by Messrs. Young and Treat, detailing the results obtained from water-rate tests of some 14 high-speed engines of different design, which had been in service three months or longer. As these water-rates were given on the indicated horsepower and on the kilowatt basis, I have added 5 per cent for friction and 5 per cent to the water-rate in each case, to facilitate a comparison on a brake-horsepower basis in accordance with the curves forming a part of this paper.

7 Mr. Dean's figures are as follows:

Engine	1	2	2	3	4	4
Capacity, h.p	129.5	106	167.4	153.3	167.68	224.7
Water-rate, lb	38	38.5	37.59	33.6	39.37	38.5

Engine	A	A	B	B	C	C
Capacity, h.p	178.8	286	108	144	77.9	116.8
Water-rate, lb	36.4	31	38.1	35.2	38.5	35.7

8 Mr. Young's figures are as follows:

Engine	1	2	3	4	5	6
Capacity, h.p	70	30	28	130	123	45
Water-rate, lb	48.3	39.9	37.8	36.3	32.2	31.9

9 Mr. Treat's figures are as follows:

Engine	1
Capacity, h.p.	30
Water-rate, lb	43

10 In order to compare the foregoing water-rates per brake horsepower with the curves of standard turbines of the Curtis type, as shown by the curves in Fig. 28 and Fig. 29 of this paper, I have tabulated the results, placing the turbine water-rate under the water-rate of the corresponding capacity of engine, and we have:

Horsepower	28	30	30	45	70	77.9	106	108	116.8
Engine water-rate	37.8	39.9	43	31.9	48.3	38.5	38.5	38.1	35.7
Curtis water-rate	41	41	41	32	31	31	30	30	30

Horsepower	129.5	144	153.3	167.4	167.68	178.8	224.7		286
Engine water-rate	38	35.2	33.6	57.59	39.37	36.4	38.5		31
Curtis water-rate	30	30	29	29	29	29	29		29

11 It will be noted from the foregoing that on the smallest sizes it has been necessary to compare the half-load water-rates of the turbine with the full-load water-rates of the engine for the reason that the smallest Curtis curve in the paper is 65 h.p., but even under these conditions the average of the four smaller engines at full load is only 0.85 of a pound better than the half-load water-rate of the turbine.

12 From this point up we have an exact comparison and at no point does the engine water-rate begin to compare with that of the turbine. The nearest approach to it is at 150 h.p., and here the turbine is 5 per cent better. The widest margin is at 160 h.p., where the turbine is 36 per cent better, while the average from 70 to 250 h.p. shows the turbine to be 22 per cent more efficient than the engine.

13 The paper states that these curves were obtained from the manufacturers and apply to new machines, while the engines were tested in service and had been in use for some time. The discrepancy, therefore, between the actual water rates obtained and the builders' guarantees on which it is customary for these engines to be sold, would lead one to infer that the engines deteriorated with use.

14 On the other hand, the Curtis turbine does not fall off in efficiency due to long service, nor is its efficiency affected by adjustments. In this connection I will refer to the statement made by

Professor Carpenter in discussing this paper at the Washington meeting that he had tested a 75-kw. Curtis turbine which had been in service some 7000 hr. and the results were not materially different from those presented by a new machine of the same capacity and design.

W. J. A. London. From Mr. Burleigh's remarks it is apparent that I did not make myself clear in connection with the curve mentioned by me earlier in the discussion; namely, a comparison between Fig. 25 and Fig. 28. In making this curve, I used only absolute tests according to the figures mentioned and made no deductions whatever except in the question of relative peripheral speeds. If the curves plotted in Fig. 28 are reproduced for a series of full-load points on a speed basis, a positive curve will be formed. On this curve is plotted the two full-load tests shown in Fig. 25. Now, then, as there are only two points given in the Terry tests, it is impossible from these tests to obtain the nature of the curve, but the point I particularly wished to bring forward was that these two points practically coincide,—one test, as a matter of fact, being better and one worse,—both of them being so near the Curtis curve as to make little difference. They are not so far away as Mr. Rice would have us believe from his diagram.

2 Mr. Burleigh raised the point as to whether emergency governors were fitted on other makes of turbines besides the Curtis. Particularly with the Terry turbine and I believe with the majority of the other makes, an emergency governor is not provided for the reason that a positive type of governor is fitted on the main shaft. The worst that can happen is the breaking of a spring, which would immediately close the valve. With a governor driven by a gear shaft an emergency governor is more essential for the reason that the gears are likely to break; hence some form of governor is used on the main shaft. If the direct-connected governor on the main shaft is likely to get out of order, why then is the emergency governor not likely to get out of order when placed in the same position? Up to the present time the Terry Turbine Co. has not had a machine burst, and with the type of governor adopted and the speeds employed, the designers consider an emergency governor an unnecessary luxury.

R. H. Rice Mr. London claims that the steam consumption of the Terry turbine is the same as that of the Curtis turbine, when operating the Terry turbine at its designed speed and reducing the speed of the Curtis turbine to two-thirds of its designed speed of 3600 r.p.m. The inaccuracy of this comparison can be readily understood when it is known that the angles of the buckets in the Curtis turbine would be radically changed if designed to run at two-thirds of the present rated speed.

2 In discussing emergency governors, it must be realized that we are dealing with much higher speeds than those usual with reciprocating engines. It has been found best in many plants to install emergency governors on reciprocating engines. If this is desirable on slow-speed apparatus, how much more desirable, and even necessary, is it on high-speed apparatus like steam turbines. Many other accidents besides the breaking of a spring can happen to a positive type of governor fitted to the main shaft, and any one of these is sufficient, to cause a dangerous increase in speed of the turbine. An emergency governor can be made to possess the utmost certainty and reliability of action, since its function is to shut down a machine and not to regulate its speed.

J. H. Libbey. The applications of small steam turbines mentioned by the author, except for driving high-pressure fans, refer to uses with auxiliary apparatus in a central power station. For this purpose a small steam turbine must be considered in competition with a reciprocating engine, and in general the choice will be decided by the following considerations: First cost, attendance required, maintenance and repairs, space, economy and influence on design of power station.

2 *First Cost.* At present, when the service permits operation at speeds approximating those for which the turbine was designed, the cost of the turbine is somewhat lower than that of a corresponding reciprocating engine.

3 *Attendance Required.* The attendance required for a small steam turbine is less than that required for any other type of steam machinery. It approaches very closely that required for an electric motor.

4 *Maintenance and Repairs.* In Par. 32, the author indicates that small turbines have been running for only three years. Obviously in this time no data of great value could be obtained to enable a decision to be made in regard to maintenance and repairs. The evidence, however, strongly indicates that they will be materially less than for a reciprocating engine.

5 *Space.* Steam-turbine-driven apparatus is generally characterized by the small space required. In a great many cases, a turbine unit can be installed where a reciprocating engine would be impossible.

6 *Economy.* An inspection of Fig. 28 and Fig. 29 shows that for the best conditions a turbine can deliver a horsepower with as little steam as, or less steam than, the same size reciprocating engine. In installations where the conditions are not favorable, the economy is reduced. Unfavorable conditions for a steam turbine are low superheat, low steam pressure, high back pressure or reduced speed of the turbine, on account of the characteristics of the driven machine. The last condition is the most likely to cause reduction in the economy.

7 It should be borne in mind that in the ordinary large central station where fairly large generating units are installed, the steam consumption of the auxiliaries does not in general amount to more than 10 per cent of that of the main generating units. In such cases, the auxiliary exhaust will heat the feed water to about 175 or 180 deg. fahr. A considerable increase of steam consumption of the auxiliaries can be permitted before there is sufficient exhaust to heat the feed water to 212 deg. fahr. In most cases, therefore, the steam consumption of these small auxiliaries is a matter of secondary consideration.

8 In the various auxiliaries generally used the inherent conditions which would affect the steam consumption would be in general as follows:

Exciter, favorable.
Circulating pump, speed low for best results.
Hot-well pump, favorable.
Forced or induced-draft fans, speed low for best results; special design of fan required.
Feed pump, speed low; however, the steam consumption of a turbine-driven multistage centrifugal feed pump is much lower than that of a reciprocating pump of the same capacity.

9 In this connection Mr. Orrok's statement in Par. 32, that there seems to be no change in steam use with length of service is of importance as it is well known that the steam consumption of engines or pumps increases greatly with wear of valves, rings, pistons, cylinders, etc.

10 Many central stations are today operating the auxiliaries

with superheated steam. Very few changes are required in the structure of a steam turbine to adapt it to superheated steam by the use of which the economy is improved. The reciprocating engine gains in economy from superheat, but greater changes in the design are required to obtain satisfactory operation, and the expense of the engine is therefore increased.

11 *Influence of Design on Power Station.* Turbine-driven exciters are generally light in weight and compact. They can be set on the engine-room floor without a heavy foundation or resulting vibration.

12 Circulating-pump units are of simple design. In many cases, a combination of auxiliaries may often be effected. There is on the market a jet condenser, the centrifugal pump and air pump of which are on the same shaft with the turbine. When in surface-condenser work the conditions are such that the speed of the circulating pump is subject to little variation, the turbine, circulating pump, and hot-well pump can be mounted on the same shaft. One manufacturer is prepared to add a rotary vacuum pump to these, either direct-connected or chain-driven. This arrangement gives practically one auxiliary for a surface condenser in place of three.

13 *Future Designs.* The small steam turbine has sufficiently justified its existence. The future will undoubtedly show types with improved economy, especially at reduced speeds, simplicity of design, rugged characteristics, ability to operate without attention, interior construction that is easily accessible and such that few repairs due to wear are required.

THE AUTHOR. The author is greatly pleased with the reception accorded his paper and the amount of discussion which it brought out. He must take exception to a comparison of water rates plotted on percentages of load as abscissæ, and a new diagram has been prepared, Fig. 1, showing the results of all the water-rate curves plotted with bucket speed or peripheral velocity as abscissæ, obviously a much better measure of the performance of these machines. The author would like to take up the question of improper entrance and discharge bucket angles in machines of the Riedler-Stumpf type, as well as the fluid friction question, both mentioned in the discussion of Mr. Rice; but these should be the subject of a mathematical paper and are not of serious importance in a small turbine. The author agrees with Prof. Carpenter rather than with Mr. Rice as to the future of the "reaction" type of turbine. He feels that Mr. Ball has failed to grasp the fact that with small rotating masses speeds of from 600 to 3000 r.p.m. are not as objectionable as a speed of 150 r.p.m. in a modern four-valve engine, or 100 double strokes per minute in a direct-acting pump.

2 Replying to Prof. Hollis' discussion, the author knows of many power plants where entire reliance is placed on turbine-driven multi-stage centrifugal pumps for feed-water service. He knows of no case where an attempt has been made to find the coal consumption of the feed pumps directly; in other words, the duty of the pumps. It has usually been obtained through the steam consumption with a knowledge of the evaporation constant of the plant. The use of Venturi meters in the feed lines and in the steam connections to the turbine-driven feed pumps would give this duty directly, and a partial installation of this nature has been made at the Waterside Station of the New York Edison Company.

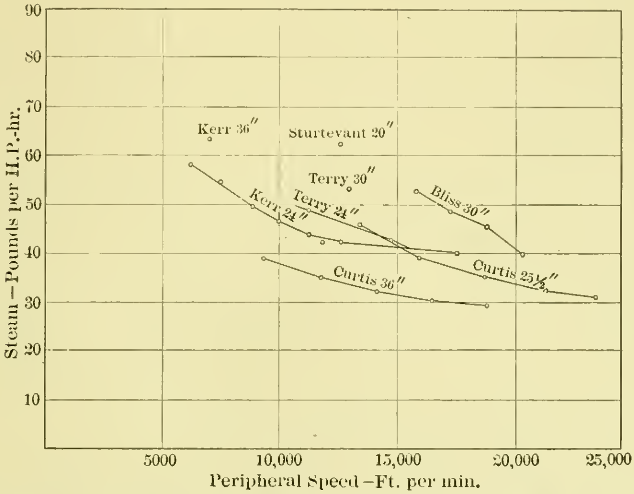

Fig. 1 Steam Consumption of Small Turbines Plotted with Peripheral Speeds as Abscissae

GAS POWER SECTION

DISCUSSION PRESENTED AT WASHINGTON MEETING

REPORT ON GAS PRODUCER DEVELOPMENT ABROAD

C. L. Straub.[1] We have received reports from abroad of progress in the marine gas-producer field, a summary of which I hope will prove of interest.

2 In Holland teaming is practically unknown and local freight trains are never run, the canals being used for moving freight from one city to another or between different parts of the same city. The canal barges range from 40 ft. in length, with an 8-ft. beam, drawing 3 ft. of water, to 150 ft. in length, with a 20-ft. beam, drawing 6 ft. of water. The majority of the barges are hand-propelled, about 9 per cent have steam equipment, while about 6 per cent are propelled by gas engines. Of the last-named, a few—about $\frac{1}{4}$ of 1 per cent—use gas producers, the others using liquid fuel.

3 The gas-engine barges range in size from 40 ft. to 130 ft., the engines from 10-h.p to 300-h.p., and the engine speed from 250 r.p.m. for the larger to 400 r.p.m. for the smaller engines. The reason for the small number of power boats is the great scarcity of fuel. Holland is without coal mines or any natural growth of timber. Hence coal is expensive and difficult to obtain, though wood is more plentiful as large quantities of lumber are shipped in from Germany. Peat is used a great deal, while compressed peat and some domestic and imported briquettes are burned to some extent.

4 The gas-engine boats using liquid fuel are more handicapped by fuel conditions than the steamboats are. The Standard Oil Co. supplies fuel in a few large cities such as Amsterdam and boats of large power can work around these fuel depots only. This limit to the radius of action prevents the extensive equipment of boats with gas engines operating on liquid fuel.

5 The producers installed on the comparatively small number of boats include principally modifications of standard German stationary types. They are not successful and apparently cannot be made to

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[1] C. L. Straub, Loomis, Pettibone Co., New York.

give continued good results with the fuels available. Producers that will operate economically on peat, wood, briquettes or poor coal, and require little attention, are in great demand. The engines are giving satisfaction. Boat owners want gas-engine equipments but not for use with liquid fuel.

6 Herr Schichlam, a large ship-builder of Scheidens, could probably be induced to try an American producer, which if successful would result in a large number of orders. There is a great demand for gas-producer equipment of capacities up to 300-h.p. for inland waterway traffic, and for capacities up to 600-h.p. for general inland and foreign traffic. Holland thus offers an attractive field, because success with these small capacities will open the way for larger equipments.

7 It is reported that the Capitaine Company in Germany are making tests of a bituminous coal gas producer, which will continue up to September, 1909. The superintendent of the company stated that although bituminous coal gas producers were used extensively in shore installations, the gas was not pure enough and was not suitable for marine gas engines. A long run cannot be made with any bituminous producer yet designed. Ship conditions are entirely different from those of stationary work.

8 A test run of two tug-boats was made from Hamburg to Kiel and return, one boat having a steam equipment, and the other a gas-producer equipment. The results are shown in Table 1. The weather was rough and the speed maintained 8½ knots an hour. The coal consumption for a period of 10 hours was as follows: Gastug, 530 lb. anthracite coal; Elfrieda, 1820 lb. bituminous coal; an economy in coal consumption of nearly 3.5 to 1 in favor of the gas-producer equipment.

TABLE 1 COMPARISON OF STEAM AND GAS PRODUCER EQUIPMENTS

	Gas	Steam
Name	Gastug	Elfrieda
Length	44 ft. 3 in.	47 ft.
Beam	10 ft. 6 in.	12 ft.
Horsepower	4 cyl., 70 b.h.p	Triple-Exp., 75 b.h.p
Towing meter pull	2140 lb.	2020 lb.

9 In discussing the possibilities of the gas engine and producer for marine use, Herr Flohn, of Germany's largest shipyard, the Stettiner Machinenbau Actien-Gesellschaft Vulcan-Stettin, said that he was opposed to gas-engine propulsion for ships for the following reasons:

a The successful operation of a bituminous producer has not yet been demonstrated to unprejudiced marine engineers.

b The engine will quickly follow the producer when the latter has been perfected, but starting, reversing and cooling must be thoroughly considered. The engines must be designed by marine engineers and not by designers of stationary gas engines.

c The multiplicity of gas-engine cylinders and the large floor space needed are serious disadvantages. The engines are absolutely inaccessible as compared with the modern marine steam engine. An important requirement is that the gas engines shall be double-acting and shall run at the same speed as steam engines of equal capacity.

d Whatever would be saved in smoke stacks and breeching would be more than offset by the large ventilating air duct in the fire room.

10 Herr Blohn, of Blohn & Voss, shipbuilders of Hamburg, said that though his company were using gas to operate a part of their works they had not developed any bituminous producers which they thought suitable for marine use. While there were stationary engineers in Germany who thought they had developed such a producer, marine engineers had not yet seen any outfit which they would endorse.

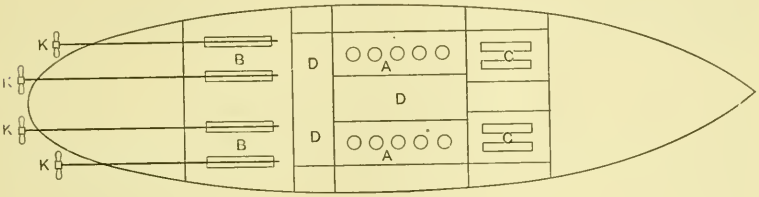
11 Herr Körting has established a marine department at Kiel, and has practically a monopoly of the government submarine work. He is experimenting and preparing to take up larger work. The German government has decided to adopt gas-engine boats for all warship launches, pinnaces, videttes, portable torpedo boats, and the like.

12 The Nürnberg Company (Vereinigte Machinenfabrik Augsburg und Machinenburg Gesellschaft Nürnberg A.G.) have installed a number of small Diesel oil engines for marine use. Both suction and pressure producers are built by them. As to fuel, the company states that anthracite, coke, charcoal and lignite briquettes are the most suitable for producers. Efforts to gasify raw pit coal have not been entirely successful, at least in medium and small-sized plants.

13 In Great Britain, Vicker Sons & Maxim, Ltd., have built 40,000 h.p. of marine high-speed gas engines. Plans have been drawn for an oil-engine torpedo-boat destroyer of about 30 knots speed. With the same dimensions and speed, the oil-engine destroyer saves enough weight and space so that the armament may be increased from the one 12-lb. and five 6-lb. rapid-fire guns of the steam destroyer to four

33-lb. and two 6-lb. rapid-fire guns. Moreover the quantity of ammunition (number of rounds per gun) is the same for both boats, although the guns and ammunition per round of the oil-engine destroyer are much heavier than those of the steam-engine destroyer. Sufficient fuel capacity is provided to allow a speed of 30 knots an hour with a radius of action $6\frac{1}{2}$ times greater than that of the steam-driven destroyer. Also more space below decks allows superior accommodations for the crew.

14 An outline of a proposed gas-engine propelled battleship is shown in Fig. 1. Here also the advantage in weight over a steam equipment made a heavier armament possible. Each propeller is driven by a 10-cylinder vertical gas engine. The air compressors are driven by gas engines. Oil engines drive the generators for supplying current for lighting, and for operating motors driving the stearing gear, windlass, pumps, etc. Table 2 and Table 3 show the difference in weight with steam, gas, and oil equipments, and the difference in armament with steam and gas equipments.



A=Gas Producers
C=Air Compressors
B=Gas Engines
D=Shell Room (Ammunition)
K=Propellers

Fig. 1 Proposed Gas-Engine Propelled Battleship

15 From a military standpoint the gas equipment shows great superiority in point of magazine location and accessibility. The benefit derived from the absence of boiler breeching and funnels is very marked. Without increasing the length of the ship, the turrets may be so disposed that the ten guns may be fired broadside on either side. A further advantage is that the temperature of the machinery space is lowered and fewer difficulties are involved in the satisfactory heat, isolation and ventilation of the adjacent magazine.

16 A marine gas-producer equipment built by the Beardmore Company under the Capitaine patents was tried out with satisfactory results. The capacity of the plant was 70 h.p., the engine having

four cylinders $8\frac{1}{4}$ in. in diameter and of 11-in. stroke. The weight of the whole was slightly over 13 440 lb. The equipment was installed in a launch 60 ft. long and of 10-ft. beam. A 10-mile run was made in one hour without recharging the producer.

TABLE 2 COMPARISON OF WEIGHT

	Steam Engine	Gas Machinery	Oil Engine
I.h.p	16,000	16,000	16,000
Weight of propelling machinery with auxiliaries, tons	1,585	1,105	750
I.h.p. per ton wt. of machinery	10.1	14.48	21.33
Area occupied by machinery, sq. ft	7,250	5,850	4,110
Area per i.h.p., sq. ft	0.453	0.366	0.257
Fuel consumption in pounds per i.h.p. per hour, based on experience to date, at full power, pounds	1.6	1.0	0.6
At ½ power pounds	1.66	1.15	0.75

TABLE 3 COMPARISON OF ARMAMENT

Steam and Gas-Driven Battleships

	Steam	Gas
No. of 12 in. guns	4	10
No. of 10 in. guns	4	—
No. of 6 in. guns	12	—
No. of 4 in. guns	—	18

Note.—The weight of a 10-in. gun is 55 per cent of that of a 12-in. gun.

17 The Beardmore Company have been experimenting with bituminous coal for some time, but have not yet been able to obtain satisfactory results, owing to tar and clinker troubles.

MARINE PRODUCER GAS POWER

By C. L. Straub,[1] Published in The Journal for May

ABSTRACT OF PAPER

This paper treats of the conditions operating against the earlier adoption of producer-gas power for marine service, together with marine gas-power plants in operation at present. All of the present plants are adapted only for anthracite coals or other low volatile fuels and there is a necessity for a good marine bituminous gas-producer plant.

The author compares the up-draft and down-draft system of stationary producer-gas apparatus, showing the relative adaptability of both for marine service. A down-draft plant modified for marine service is also described.

The drawings of a 306-ft. boat fitted with a 1000-h.p. steam plant are given as a comparative example, having been modified to include the installation of a complete producer-gas power plant, with figures showing the space occupied and the weight of the complete apparatus in each case.

The paper states that a 300-h.p. marine producer-gas power plant of this type has been in operation for some time.

DISCUSSION

George Dinkel. I would like to ask the author if there are any gas-producers working with the small grades of the steam sizes of anthracite coal, such as No. 3, 2 and 1 buckwheat, especially as he states in Par. 8 that there are in commercial operation in this country today two distinct types of stationary power gas-producers suited by their design for operation on almost any class of solid fuel. Where are those producers being used on the same grade of steam sizes, and what has been the result?

Henry Penton.[2] As the members probably know, freight is carried on the Great Lakes at a lower cost than anywhere else in the world, and over 75 per cent of the merchant steam tonnage of the United States is built on the Great Lakes. We are, of course, constantly seeking methods of reducing carrying costs, and so far as the ship is concerned the most important item of expense is that of power. We have for some time been firm believers in gas power: power for propulsion, however, is only one of the problems to be met; the problem of the application of gas power to the auxiliary service has given us more concern. At present our ships are handled entirely by steam, both in port and out, and we must have power available at all times.

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[1] C. L. Straub, Loomis-Pettibone Co., New York.

[2] Henry Penton, Babcock & Penton, Cleveland, O.

2 We believed we could depend upon the combustion engineer to perfect the producer gas engine when the opportunity arrived; but it has arrived and while we believe the producer to be satisfactory we are not yet satisfied with the engine.

3 We first considered the installation of gas power in one of our modern ships where the average horsepower (indicated) is in the neighborhood of 2000, but subsequently decided to select a smaller type, believing that we should practice creeping before walking. While the ship to which the author has alluded represents the best standard practice in design, she is not a representative lake steamer in that she is relatively small. Her engines develop approximately 1000 i.h.p. Her carrying capacity is about 4080 tons on 18 ft., while our modern ships run to 12,000 and 13,000 tons on the same draft. The fuel is necessarily bituminous coal, fairly uniform in heat value and averaging about 13,500 B.t.u. Anthracite and coke are out of the question both as to delivery and cost.

4 It should be noted that the fuel consumption given by the author includes fuel used for all purposes aboard ship charged against the actual indicated horsepower. This is the customary method of stating the consumption and is used merely for purposes of comparison. The propelling engines actually do their work on an average of 1.5 lb. to 1.65 lb. per i.h.p. per hr., including the auxiliaries.

5 In Par. 25 mention is made of the installation of a 50-kw. direct current generator. I think, however, it will be necessary to use at least two of this size, depending somewhat on the method adopted for handling the windlass, which calls for the largest individual motor of any of the apparatus. There must be no such thing as a generator shutdown. As just stated, every function of the ship, including propulsion, is now performed by steam, and power must be available every instant from the time the ship goes into commission in the spring until she is laid up the following winter. If we take out steam we must provide something just as available in its place. While a great

part of the time the output will be small, we must be able to take care of the maximum requirements.

6 It may be wondered why, as stated in Par. 26, the auxiliary boiler is required for heat and for washing down decks. These ships run until well into the winter and when the weather becomes severe they ice up badly, and it is not uncommon to make port with 200 or 300 tons of ice aboard. The quickest method of clearing away is with the hot-water hose. I hope we shall be able to use the exhaust gases for generating steam at sea and thus operate the boiler without the use of coal; but I do not yet know whether this is feasible.

7 With reference to figuring the elimination of cost in two years, the operation is brought about in this way: some of our ships get in more, some not so many, but the average is not far from 20 round trips per year; and taking into consideration the reduction in weights, which means additional revenue-producing cargo capacity; reduced space, which in some trades is also additional cargo capacity; and reduction in fuel, which is both reduced expense and additional cargo, I have succeeded in convincing myself that we can get even in about 1½ seasons; but two seasons is perfectly satisfactory, and you can readily see that the addition of one or more trips in the year will go a long way toward the extinction of that cost.

Irving E. Moultrop. Examination of Table 1 gives some very interesting information. It is rather surprising that the total weight of the complete gas-power plant is so much less than that of the steam plant. Of course, the steam plant has a number of auxiliaries which the gas plant does not require, and these auxiliaries are quite heavy, yet up to the present time, in stationary practice, the total weight of a gas engine has been very much in excess of that of a steam engine for the same power. The two prime movers discussed in this paper operate at the same revolutions per minute, so one would naturally assume that the extra weight in the gas engine would go far toward making up for the saving in weight due to the omitting of a number of steam engine auxiliaries. As the total weight of the gas engine room machinery is only about 60 per cent of that of the steam engine room machinery, one naturally wonders if the factor of safety in the gas engine design has not been reduced to save weight, or if this is not the case, if some special weight-saving features have not been introduced in the gas engine design, which might have been used to equal advantage in he steam engine.

2 Comparing the producer room with the boiler room it is inter-

esting to note that the total grate area of the producers is only about five-sixths of that of the steam boilers. Stationary practice has shown that the best producer results are obtained at a very much lower rate of combustion per square foot of grate than in good steam boiler practice. It would be interesting to know how the engineer of the gas power plant expects to obtain capacity out of its producers when the full consumption per square foot of grate area in the producer will exceed what is considered good practice on the grate of steam boilers.

3 In comparing the total weight, machinery and fuel, in the gas-power plant with the steam plant, and also the total space occupied, it should be noted that in the gas plant the bunker capacity is less than half that in the steam plant.

Herbert M. Wilson.[1] Perhaps it would not be a breach of confidence for Mr. Straub to tell us something concerning the gas producer for the new non-magnetic vessel of the Carnegie Institute. This vessel is being constructed with as little iron as possible, for use in magnetic surveys; and I understand the gas producer and gas engine were selected for auxiliary power because of the small weight of metal required and the possibility of substituting bronze and other non-magnetic metal for iron and steel. Their vessel is about to be launched, and perhaps Mr. Straub could tell something of the gas producer engine plant which is under construction for actual operation.

E. T. Adams. Great changes in the weight required have come about in the past few years. The first designs in any line of manufacture uniformly carry unnecessary weight in the various parts and it is safe to say that the gas engine of today, built with the same factor of safety, would be 25 per cent lighter than any engine of the same horsepower built three years ago.

2 This applies to engines in use for ordinary commercial purposes, as electric lighting or power. In view of this fact the statements of the author on this point are not at all surprising. The increasing use of steel and the modification of design based on experience have led to great reduction in weight of engines for special purposes, such as are here specified.

The Author. In reference to Mr. Holmes' remarks on the speed of vessels, taking a given hull and a given power equipment, the craft will go at a certain speed, the character of the equipment notwithstanding. I can answer Mr. Holmes' question better by drawing a comparison, with the able assistance of an article by Capt. A. B. Willits, U. S. N.[1] Mr. Willits states that the floor space occupied by the boilers in the New Hampshire equals 0.33 sq. ft. per h.p., and that the weight per b.h.p. is 110 lb. The power of these boilers is rated at their forced capacity. If we install a producer plant and rate it at its forced capacity at 40 lb. of fuel per square foot of grate, it will occupy 1/10 per square foot per b.h.p., for such a plant as the New Hampshire would require, and weigh 30 lb. per b.h.p.

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[1] U. S. Geological Survey, Washington. D. C.

2 From these figures it is apparent that a marine producer-gas plant can be installed in at least the same space and of certainly not greater weight than a modern marine steam boiler plant. These figures refute Capt. Willits' figures of the Westinghouse gas plant, which occupied 1 sq. ft. per b.h.p., and weighed 28.5 lb. per h.p., and the R. D. Wood producer which occupied 1.84 sq. ft. per b.h p. and weighed 194 lb.

3 Mr. Dinkel asked regarding the small anthracite coals in gas producers. I can refer him to the generator of the R. D. Wood plant at Jersey City, which has been operating at the plant of the Erie Railroad for five or six years on a mixture of No. 1 and No. 2 buckwheat coal. The Lehigh Coal and Navigation Company has installed a gas producer which has operated on rice coal and has been running for almost two years. We have two plants in operation, one at Hartford, Conn., and one near Philadelphia, running on a fine grade of anthracite coal, mixtures of Nos. 1, 2 and 3 buckwheat.

4 Regarding the factor of safety in gas-engine parts, which Mr. Moultrop brought up, the six-cylinder engine in Fig. 1, the double-acting engine, weighs less than 30 lb. per b.h.p. Of course, that was a comparatively high-speed engine and delivered 300 b.h.p. at 320 r.p.m. This 1000 h.p. engine will be fitted with cast-steel parts, in almost every instance where cast iron was used on the steam plant, and this makes for a big reduction in weight at a very slightly increased cost.

5 The producer and equipment for the Carnegie, about which Mr. Wilson asked, is almost finished and will be in the boat when she is launched on May 10. The producer shell is about 6 ft. in diameter and is of copper. The pipe and scrubber are of composition metal, containing no iron or steel. The only steel or iron parts on the pro-

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[1] Gas *vs.* Steam for Marine Motive Power, U. S Naval Inst. Proc., December 1908.

ducer are manganese steel grates, doors and door frames, near the hot portion of the fire in the producer equipment, and this manganese steel is less than one per cent magnetic, when compared to mild steel, so that of it we have been allowed the use of 1500 lb.. The engine will have bronze cylinders and will not be lined with cast iron, as the published reports indicate. We are going to run cast-iron pistons in the bronze cylinders. The cylinders are comparatively so thin and so close to the water jackets, that we anticipate no trouble from deterioration. The only steel or iron parts about the engine will be the cams, rollers and valves. The valves will be of cast iron. The steel cams and rollers will be hardened and ground. On a commercial basis, using terms equivalent to mild steel, as far as magnetic force is concerned, we will have less than 200 lb. total of iron or steel in that vessel. The published reports make further detail unnecessary. The boat will be ready to sail July 1.

OPERATION OF A SMALL PRODUCER-GAS POWER PLANT

By C. W. Obert, Published in The Journal for May

ABSTRACT OF PAPER

This paper presents a general description of a producer-gas power plant, in the new Westchester market building of Swift & Company, Bronx Borough, New York City, in operation for over a year and containing both refrigeration and electric power and lighting services. The conditions are unusual for suction gas apparatus, both the refrigeration and electrical services requiring 24-hr. operation continuously, daily throughout the year. The author outlines the operating and maintenance systems developed for keeping both producers and engines in proper condition, and for insuring absolute certainty of their continuous operation which is there particularly necessary.

DISCUSSION

J. A. Holmes. The success of the small producer plant using anthracite coal is practically assured. Not long since (1905), in visiting a number of these plants in Cologne, Germany, I found a newspaper press that had been operated entirely for more than a year by a small gas-producer plant burning small-sized anthracite coal; one of the larger hotels there had been using such a plant for a longer period with entire satisfaction to supply all its electric light and power; in a large commercial house, electric lamps, elevators and all other machinery connected with the establishment were operated by one of these plants. In each of these cases the producer, engine-driven generators and other equipment in the power room, were all operated by one man, and the plant was regarded as a success in efficiency and economy of labor and fuel. In the United States, also, many producer plants have been using anthracite coal for some years. In our own investigations at the Government testing station, anthracite coal has been regarded as a fuel so simple and so easily regulated that we have done little work on it, turning our attention mainly to the bituminous coal producer problems.

2 In regard to producer work with bituminous coal, we have investigated fuels rather than different types of producers. Using every imaginable grade of bituminous coal and lignite in making short-time tests, we have encountered many difficulties due to a lack of familiarity with the special manipulations required by certain fuels. These difficulties, one being to secure a uniform quality of producer gas, would not be met in using the same fuel year after year. In early work, with the Taylor producer, we could get gas of absolutely uniform character not more than an hour at a time, and the variation in 24 hours was at times from 125 B.t.u. to more than 200 B.t.u. per cu. ft. of gas, these variations being largely due, no doubt, to inexperience in the handling of any special fuel. During the past three years, however, with more experience, the regularity and efficiency of this gas has been greatly increased.

3 Another difficulty, and one not entirely separable as yet, is the slagging or clinkering of the ash in the producer. The ash in certain coals slags more readily than in others; and different ashes slag more readily at different temperatures. One of the greatest needs in producer development at the present time is that of a regular mechanical feed of coal and removal of the ashes which now accumulate in some producers, to be cleaned out after the producer has cooled down. We have sometimes found the slag from certain coals, burned at high temperatures, accumulating irregularly on the brick walls lining the producer, at the rate of 6 in. to 10 in. during a week's run. If mechanical arrangements can be devised, by which the ash may be removed from the base of the producer as regularly as from the base of a boiler, then the use of a double producer will be largely avoided. Decided progress is being made in overcoming this difficulty.

4 Still another line of progress is in the reduction of weight and bulk of the producer making its use possible instead of that of steam boilers for propelling ships. Mr. Straub's paper indicates what is being accomplished along this line. Already the anthracite producer and gas engine have been reduced in size and weight to less than those of the steam boiler and reciprocating engine; and the outlook is hopeful for the producer burning bituminous coal.

John H. Norris. I have been connected with the manufacture of gas engines for a number of years, and the principal trouble we have had in the operation of gas engines of any size is to overcome the notion that a gas engine needs no care. At the present time, however, gas engines are running successfully because in most installations they receive proper attention. I am glad to see put on record the statement that a gas engine installation needs as close attention as a steam engine installation.

William A. Bole. The Westinghouse Machine Company has been working on the gas-producer problem as well as on the gas-engine problem for some time, and now believes itself ready to offer gas producers that will be as practicable and as easily manipulated and capable of as long-continued runs as any boiler plant. A producer plant of 175-b.h.p. capacity has been in operation at our works for practically a year, without pulling down the fires. During that period all sorts of runs have been made, continuous runs at full capacity for ten days or two weeks, and the more ordinary runs in which producer and engine are shut down at night; and the producers have burned not only the comparatively good coals of the Pittsburg district and the better coals of the Pocahontas region, but several of the Western and Southwestern lignites and even peats from New England. The latter have not been so successfully burned, but the success in burning Colorado lignites has been very decided. This producer was shut down and cleaned out, simply by shoveling the ashes out of the water seal, and observations of the condition of the interior walls showed that it might just as well have been operated continuously for five years instead of one, or as many years as the firebrick lining would last. The requirements for continuous performance seem to have been admirably met in this design.

2 This producer is designed for the burning of bituminous coal alone, and resembles a small producer inverted and placed on top of a large one, making a double-zone producer especially adapted for the gasification of bituminous coal without passing tar of any description out of the producer shaft. Apparently the only solid material emitted from the gas is a small amount of lamp-black which is successfully removed by the use of a static or stationary scrubber, and the cleanliness of the gas is proved by the fact that practically all the gas was converted into brake horsepower by being employed in the actual operation of a gas engine, without troublesome deposit of any kind upon the ports or other parts of the gas engine.

3 Whether such a producer would be available for marine purposes I do not know: the only question seems to be whether the motion of the ship would interfere seriously with the descent of the fuel from top to bottom. The producer has been subjected to practically every test, and we believe we are about ready to offer it for both large and small plants.

A METHOD OF IMPROVING THE EFFICIENCY OF GAS ENGINES

By Thos. E. Butterfield,[1] Published in The Journal for April

ABSTRACT OF PAPER

The tendency in gas-engine practice to secure higher efficiency by reducing the clearance and increasing the compression, has led to various expedients to avoid premature ignition and other troubles incident to such practice. The author discusses the method of diluting with an inert gas the charge drawn in during the suction stroke of an Otto cycle engine. He refers to the invention of this method by John Saltar twenty years ago and to experiments subsequently made to show its practical working effects. Calculations are given based upon the dilution of the charge with inert gas and comparative tables showing the effect of such dilution.

DISCUSSION

A. M. Green, Jr. The equation of Par. 20 of this paper is not clear to me in derivation. It seems to me that when the total volume of gas and air is $1 + C$, the volume of the clearance gas will be $\frac{15}{14} C \frac{T_1}{1200}$ and the volume of the air will be $1 + C - \frac{15}{14} \times \frac{T_1}{1200} C$, and both will be at the temperature T_1, so that the equation will be

$$\frac{15}{14} C \frac{T_1}{1200} (1200 - T_1) = \left(1 + C - \frac{15}{14} C \frac{T_1}{1200}\right) (T_1 - 530)$$

from which

$$T_1 = \frac{530\,(1 + C)}{1 + C - \frac{670}{1200} C \frac{15}{14}}$$

which is the same as that found by Mr. Butterfield in another form.

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[1] Chief Engineer, Otto Gas Engine Works, Philadelphia, Pa.

My only question is, the reason for the form of equation 1 of Par. 20, the basis of which is not clear.

WM. O. BARNES. It may be of general interest to show that dilution of the mixture in a gas engine will not be attended by a loss of efficiency provided the speed of combustion is not decreased.

2 Let:

V_1 = the volume of the cylinder and compression space at the end of the suction stroke = unity.
V_2 = the volume of the compression space.
P_1 = the pressure at the end of the suction stroke.
P_2 = the pressure at the end of compression.
P_3 = the explosion pressure.
T_1 = the temperature at the end of suction stroke.
T_2 = the temperature at end of compression.
T_3 = the explosion temperature.
n = the ratio of the specific heats at constant volume and pressure.

3 Assuming adiabatic compression and expansion we have, during the compression,

$$P V^n = P_1 V_1^n \doteq P_1$$

4 The work of compression is

$$\int_{v_2}^{v_1} P\,d\,V = \int_{v^2}^{v_1} \frac{P_1}{V^n}\,d\,V = \frac{1}{n-1} P_1 (V_2^{1-n} - 1)$$

and since

$$P_3 = \frac{T_3}{T_2} P_2$$

the work of expansion is

$$\frac{T_3}{T_2}\frac{1}{n-1} P_1 (V_2^{1-n} - 1)$$

the net work of the cycle is

$$W = \frac{T_3 - T_2}{T_2}\,\frac{1}{n-1}\,P_1 \left(\frac{1}{V_2^{n-1}} - 1\right)$$

5 Now,

$$T_2 = T_1 \left(\frac{1}{V_2}\right)^{n-1}$$

and assuming an absolute temperature at the end of the exhaust stroke of 1200 deg. fahr., and of 530 deg. for the mixture as it enters the cylinder, we may write:

$$V_1 T_1 = 1200 V_2 + 530 (V_1 - V_2)$$

$$T_1 = 670 V_2 + 530$$

$$T_2 = (670 V_2 + 530) \left(\frac{1}{V_2}\right)^{n-1}$$

Substituting for $\frac{1}{T_2}$ in the expression for net work:

$$W = (T_3 - T_2) \frac{1}{n-1} P_1 \left(\frac{1 - V_2^{n-1}}{670 V_2 + 530}\right)$$

6 The net work is proportional to the rise in temperature during combustion, $(T_3 - T_2)$, which is in turn directly proportional to the amount of fuel in the mixture. Consequently in an ideal engine in which no transfer of heat takes place between the gas and cylinder walls, dilution of the mixture would not affect the efficiency; provided of course the combustion be not rendered imperfect or be retarded. Since the temperature attained by the burning of a mixture is lowered by dilution, such dilution will, under usual conditions of wall temperature, increase the efficiency of an actual engine by lowering the jacket losses.

7 The influence of the degree of compression on the work produced and on the efficiency is measured by the factor:

$$\frac{1 - V_2^{n-1}}{670 V_2 + 530}$$

Values of this factor corresponding to different degrees of compression are given in the following table (n taken as 1.3), in which the first column gives values for volume of compression space assuming the cylinder volume to be unity:

V	*Factor*	*V*	*Factor*
0.5	0.00022	0.25	0.00049
0.45	0.00026	0.2	0.00058
0.4	0.00030	0.15	0.00069
0.35	0.00035	0.10	0.00084
0.3	0.00041	0.05	0.00105

8 Acceptance of an imaginary limitation is sometimes a most effectual means of retarding progress. The prevalent idea that the

amount of compression is limited by the necessity of avoiding pre-ignition is a case of this kind. The only harm that has ever been caused by pre-ignition from high compression has resulted from the fact that the parts of the engine were not correctly proportioned to permit economical combustion.

9 Assuming adiabatic compression and expansion, *a b c d c e* (Fig. 1) is the form of diagram given by an engine in which pre-ignition is taking place. The net work developed can be computed with the above formula by giving V_2 the value corresponding to the volume at *b*. This work is obviously greater than would have been developed had the compression been limited to a point where there was no danger of self-ignition. Of course in an actual engine, running under these conditions, a certain loss of heat to the cylinder walls will take place during the compression after ignition and the re-expansion to ignition volume, but when pre-ignition takes place, it is an indication that approximately the utmost efficiency is obtained, compatible with the initial temperature and composition of the fuel, and the existing conditions of the cylinder walls.

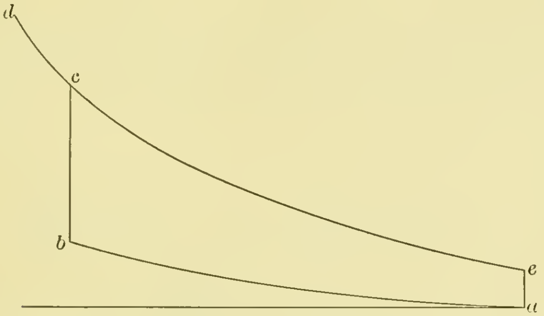

Fig. 1 Form of Diagram Given by an Engine in which Preignition is Taking Place

10 The loud poundings which have sometimes been experienced in attempts to use high compression are not necessary accompaniments of the increased speed of combustion due to such compression, but are simply indications that the designer failed to provide sufficient rigidity of parts and extent of bearing surface. No matter what speed of combustion may be obtained, the gaseous contents of the cylinder cannot deliver a blow or exert an inertia effect on the piston of any important magnitude. Hence the question of raising the degree of compression, even to the point of self-ignition, and the com-

plete realization of the gain in efficiency, thereby made possible, is merely a matter of machine design.

11 The desirability of diluting the mixture with inert gas, for the purpose of slowing up combustion, is questionable, especially, since if full advantage be taken of the possible gain in efficiency due to increased compression, it will be found that the first cost of the engine per horsepower will show a decrease due to its superior rating. On the other hand, the dilution of the mixture with air provides a means of regulation, and of running under part-load without loss of efficiency.

THE AUTHOR. The reason the first equation in Par. 20 is in a different form from Mr. Green's corresponding equation is that he used for the basis of his equation the volumes of clearance gas and fresh mixture after the interchange of heat, while I consider them before the interchange of heat. The following derivation of the final equation is better than either form suggested: Since the total volume of gas contained in the cylinder at the end of the suction stroke is $1 + C$, we have at temperature T', by Guy Lussac's law, volume of clearance gas $\frac{15}{14} C \frac{T_1}{1200}$. volume of mixture $(1 + C - \frac{15}{14} C) \frac{T_1}{530}$

2 Then

$$1 + C = \frac{15}{14} C \frac{T_1}{1200} + \left(1 + C - \frac{15C}{14}\right) \frac{T_1}{530}$$

$$T_1 = 530 \frac{(1 + C)}{1 + \frac{675}{1680} C}$$

which is exactly the same as the result first given.

3 All the results given in Mr. Barnes' first seven paragraphs were already fully given in the paper.

4 His statement that the loud pounding caused by pre-ignition in a gasoline engine is due merely to weak construction seems contrary to experience. The trunk piston does not permit enlargement of the piston-pin bearing, and there would be practically no buyers for a small gasoline engine provided with a separate cross-head. Besides this, the principal part of the pound is probably due to elastic deflection of the walls of the cylinder head and piston. The thickness of these walls cannot be indefinitely increased. But an engine operating by self-ignition will be exposed to all the troubles that have been

experienced with hot-tube ignition. The maximum pressures of explosion and the highest available mean effective pressure, would always vary within limits that might lie outside the bounds of safety on the one hand, or of satisfactory development of power on the other hand.

OFFSETTING CYLINDERS IN SINGLE ACTING ENGINES

ABSTRACT OF PAPER

By Prof. Thurston M. Phetteplace, Published in The Journal for February

This paper presents the results of a thorough investigation of the question of offsetting cylinders in single-acting engines which seemed desirable on account of the increasing practice among automobile builders. Curves of the side-pressure of the piston on the cylinder wall, considering the inertia forces due to the weight of the reciprocating parts, are shown for different conditions of engine speed, weight of reciprocating parts, amount of offset, and ratio of length of connecting rod to crank. The maximum side-pressure affecting the design of the piston and the average side-pressure indicating lost work and wear are compared for different cases.

Curves of the inertia due to the weight of the reciprocating parts are plotted and comparative vibration in engines having cylinders offset with those having no offset are discussed.

Finally four definite cases are compared, showing the effect of offsetting on the length of the different parts, on the curves of inertia forces, of side-pressures, and of turning-effort.

The derivation of formulæ are tables and given in an appendix.

DISCUSSIONS

Winslow H. Herschel. In December 1907, I had occasion to investigate the question of offsetting cylinders for large-sized gas engines, and as the conditions are somewhat different from those of the automobile engines considered by Professor Phetteplace, the results may be of interest. I shall consider only the variations in maximum and average pressure on the cylinder walls, since, as indicated in Par. 62 of the paper, these are the main questions at issue.

2 For the sake of simplicity I used the graphical method mentioned in Tolle's Die Regelung der Kraftmaschinen, page 32. The

computations were based on an actual card from a four-stroke cycle producer-gas engine, and upon the following data:

R.p.m. $= N = 225$
$W/A = 4.18$
$R = 12$ in. $= 1$ ft.
$L/R = 5$
$0.00034\ W/AN^2R = 71.8$

This last value, 71.8, happens to be very nearly the average of the two corresponding values, 34.4 and 111.38, given by the author in Table 3. Computations were also made using speeds of 450 and 1000, giving inertia constants of 289 and 1430 respectively, but it soon became evident that there could be no gain from offsetting under these conditions, and the investigation was restricted to the speed of 225.

3 As I understand the paper, the author has considered only vertical engines, or horizontal engines where the weight of the reciprocating parts is so small that its direct effect in increasing or decreasing the pressure on the cylinder walls need not be taken into account. In the present case, however, a distinction must be made between vertical and horizontal engines. For the latter, when the side pressure acts downward, due to gas pressure or inertia forces, the weight of the piston must be added, but when the side pressure acts upward, the piston weight is subtracted. It should be noted that for a vertical engine, for a given value of $0.00034\ W/AN^2R$, that is, for a given inertia constant, as I have called it, it would make no difference whether this value were obtained with a large value of W/A and a small value of N, as in my case, or with a small value of W/A and a large value of N, as in the cases used by the author. But on the other hand it would make considerable difference for a horizontal engine where the value of W enters into the computation apart from the inertia constant.

4 By using the same indicator card as for the four-stroke cicle computations, and disregarding the second and third strokes, I obtained, somewhat approximately, the side pressures for a two-stroke cycle engine.

5 Fig. 1 shows the variation in maximum pressure on cylinder walls, or side pressure, due to variations in offset. The ordinates above the base line ST are proportional to the side pressures. The line AB shows the maximum side pressure for a vertical engine at about the middle of the first stroke. As the offset increases the

angle of the connecting rod for this middle position decreases, while the angle at the end of stroke increases, so that for large offsets the maximum side pressure is found at end of stroke, with values as shown by line *BC*. Similarly for a horizontal engine we get the lines *DE* and *EF*. For the maximum side pressure due to inertia forces we have line *GH* for a vertical, and line *JK* for a horizontal engine.

6 It will be noticed that line *JK* is not parallel to line *GH*. The reason for this is that for the line *JK* we must use the inertia force near the end of the second stroke, which gives a downward pressure on the cylinder walls to be added to the weight of the piston, and this downward pressure is not as large as the upward pressure near the beginning of the second stroke, which was used for the line *GH*.

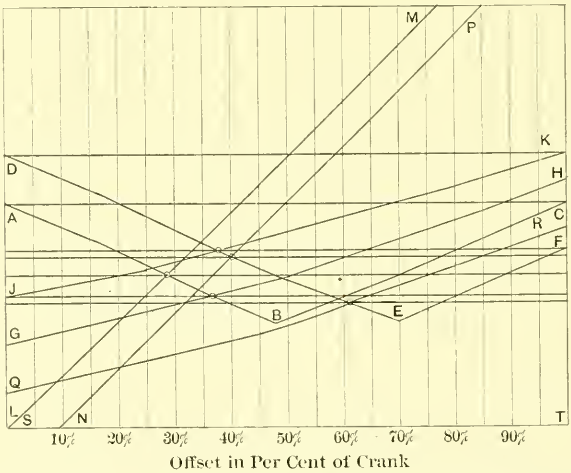

Fig. 1 Diagram Showing Variation in Maximum Pressure on Cylinder Walls, Due to Offsetting Cylinder

7 In the case of a two-stroke cycle engine, where we must use the fourth instead of the second stroke, our maximum inertia force will be near the beginning of the fourth stroke acting upward, so that the weight of the piston must be subtracted, giving line *QR*.

8 If we imagine a somewhat earlier ignition than that shown in Fig. 2 of the paper, the maximum side pressure at or near the beginning of the first stroke will be increased. Whether for this reason or not, I found that with large offsets the maximum side pressure of the first stroke was at the beginning of the stroke, acting upward, with

values as shown by line *LM* for a vertical, and line *NP* for a horizontal engine.

9 Fig. 1 corresponds to Fig. 16 of the paper and may be used in the same way to determine the most favorable offset for the various conditions. Table 1 gives the offset and the per cent reduction in side pressure in each case.

TABLE 1 OFFSET AND PER CENT REDUCTION IN SIDE PRESSURE

Curves	Dominating Factors	Case	% Offset	% Gain
AB and *GH*	Gas middle first, inertia beginning 2nd	Vertical late ignition, 2–4 Cycle	37.0	41.5
AB and *LM*	Gas middle first, gas beginning 1st	Vertical early ignition, 2–4 Cycle	28.7	31.6
DE and *JK*	Gas middle first, inertia end 2nd	Horizontal late ignition, 4 Cycle	37.7	34.7
DE and *QR*	Gas middle first, inertia beginning 4th	Horizontal late ignition, 2 Cycle	61.3	54.3
DE and *JK*	Gas middle first, inertia end 2nd	Horizontal early ignition, 4 Cycle	37.7	34.7
DE and *NP*	Gas middle first, gas beginning 1st	Horizontal early ignition, 2 Cycle	40.6	37.2

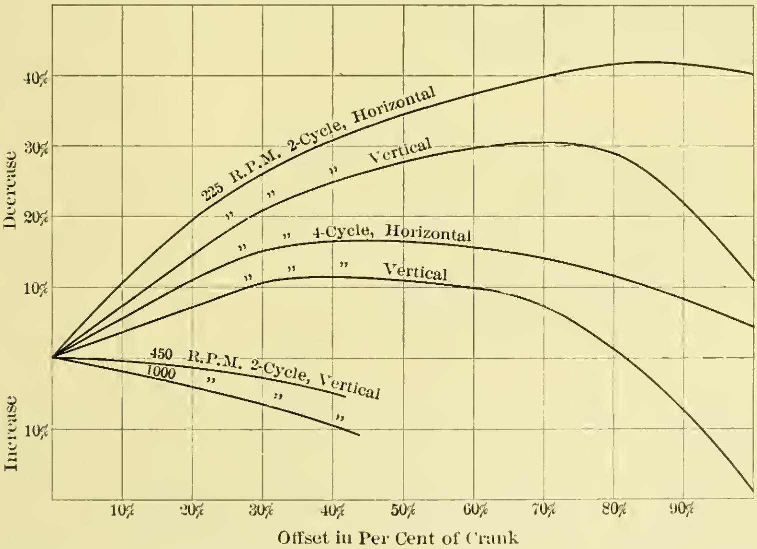

FIG. 2 DIAGRAM SHOWING CHANGE IN AVERAGE PRESSURE ON CYLINDER WALLS DUE TO OFFSETTING CYLINDER

10 The author (Par. 22) finds the most favorable offset to be 50 per cent of the crank length for slow speed, and in Par. 24 and Par. 25 he finds it to be about 20 per cent for high speed. These

values may be compared with the first line of Table 1; for the case of a vertical engine with late ignition, the offset is 37.0 per cent, which is nearly the average of 20 per cent and 50 per cent, as might have been expected from the inertia constants.

11 Fig. 2 shows the decrease or increase in average side pressure or total loss of work from side pressure, in per cent of lost work with zero offset. While the use of a different indicator card with a later ignition might have made some difference, it obviously could not have changed the result so materially as in the case of maximum side pressure. Thus the curve marked four-cycle vertical may be fairly compared with the result in Table 9 of the paper, that the most favorable offset lies between 30 and 50 per cent.

12 The curves marked 450 and 1000 r.p.m. show the results of the few computations concerning these speeds not considered in Fig. 1.

13 Both Table 1 and Fig. 2 appear to indicate that more could be gained from offsetting with a two-cycle than with a four-cycle engine. But at present it is difficult to make general statements about this type of engine, and whether or not this advantage will be attained will depend upon the inertia constant and indicator card shown by these engines.

PRINCIPAL CONCLUSIONS

a An offset cylinder may be employed with least benefit on a high-speed, four-stroke cycle vertical engine.

b It may be employed with most benefit on a slow-speed two-stroke cycle horizontal engine.

c The maximum advantageous offset is limited by the side pressure near the beginning of the first stroke.

John H. Norris. I have been designing and building both two-stroke and four-stroke cylinder engines with offset cranks for a nums ber of years. Our concern was so impressed with the advantage that in 1886 they bought the patent right to apply the offset stroke to gas engines. We are still building a few small sizes with offset crank, but there is no practical gain and as fast as we can re-design the engines we find we can get better economy and a more convenient engine, by placing the cylinder directly over the crank shaft. If you want to reverse the direction of rotation of an engine with an offset crank, you are in trouble at once. We have built an offset engine as large as four-cylinder, 14 by 22, and scrapped. I would like to say, in connection with the large engine above mentioned, that it was built in 1896 and was one of a pair that were to run a suburban electric railroad in the West, on a suction gas producer. We built at that time a suction producer that was reasonably satisfactory. We have had a great deal of success, however, with our small single and double-cylinder engines with offset cranks, of which we have built a large number, though we are just putting on the market engines to replace them, in which we have placed the cylinder directly over the center. We used an offset of from 20 to 25 per cent of the stroke. With this offset the side strain is quite sufficient on the upstroke. These were all vertical engines.

The Author would suggest that the fact that the cylinders were offset was not the real cause for scrapping the 4-cylinder 14 by 22 engine mentioned by Mr. Norris. Of course if stock engines were built, some to rotate in one direction and some in the other, or if it is desirable to build engines that may be reversed, offsetting may not practically be taken advantage of, as Mr. Norris points out. Furthermore, in spite of Mr. Norris' experience and his desire to eradicate offsetting from his product, this practice, in small vertical 4-cycle automobile engines, at least, seems to be increasing.

COMMENT ON CURRENT BOOKS

Automatic Screw Machines and Their Tools. By C. L. Goodrich and F. A. Stanley. *Hill Publishing Co., New York,* 1909. 8vo., cloth, vii + 255 p., illustrated. Price $2 net.

In the May number of The Journal a book by these authors on Accurate Tool Work was reviewed, and the present volume is of very much the same character, but dealing with another department of machine and tool work. Mr. Goodrich is department foreman with the Pratt and Whitney Co., Hartford, Conn., and Mr. Stanley is associate editor of the American Machinist. Both authors are expert tool-makers and designers and the matter which they have presented has been contributed mainly by them and to some extent by others, to the American Machinist, but revised, rewritten and added to for publication in book form. The volume is prepared in two parts, the first dealing with different types of machines and their special tools and the second with the design and construction of tools in detail, and their use.

Contents, by chapter headings: The Pratt & Whitney Automatic Screw Machine; Camming the Pratt & Whitney Automatic Screw Machine; The Brown & Sharpe Automatic Screw Machine; Laying out the Brown & Sharpe Screw Machine Cams; The Brown & Sharpe Automatic Screw Machine with Constant-Speed Drive; The Cleveland Automatic Turret Machine and its Cam Adjustments; The Gridley Automatic Turret Lathe; The Alfred Herbert Automatic Screw Machine; The New Spencer Double-Turret Automatic Screw Machine; The Cleveland Double Spindle Plain Automatic Machine; The Acme Multiple-Spindle Automatic Screw Machine; The Universal Multiple-Spindle Automatic Screw Machine; The Cleveland Automatic Machine with Magazine Attachment; The Alfred Herbert Magazine Automatic Screw Machine; The Potter & Johnston Automatic Chucking and Turning Machine; The Gridley Semi-Automatic Piston Ring Machine; The Prentice Multiple-Spindle Automatic Turret Machine; Points in Setting Up and Operating Automatic Screw Machines; Speeds and Feeds for Screw Machine Work; Spring Collets and Feed Chucks; Box Tools and Other External Cutting Appliances; Drills, Counterbores and Other Internal Cutting Tools; Screw Machine Taps and Dies; Forming Tools and Methods of Making Them; Nurling Tools and Their Applications; Why Chips Cling to Screw Machine Tools.

Internal Combustion Engines, Their Theory, Construction and Operation. Tables. Formulæ. 379 illustrations. By Rolla C. Carpenter, M.M.E., LL.D. and H. Diederichs, M.E. *D. Van Nostrand Company, New York,* 1909. Second edition revised. Cloth, 579 p. Price $5.

The theoretical principles of the internal combustion engine and their application to practical construction are treated but the proportioning and the strength of parts are not considered. The first five chapters are taken up with definitions and theory. Following this are three chapters treating respectively of solid, liquid and gaseous fuels. In the first the most important types of producers are illustrated and described. The chapter on liquid fuels deals largely with various vaporizing devices for crude oil, gasoline, kerosene and alcohol, the last-named in some detail. Valuable data will be found in the chapter on cost of installation and operation. One table compares the costs of 200-h.p. and 120-h.p. steam and gas plants. This second edition is a thorough revision of the first edition published a year ago.

Contents by chapter headings: Introduction, Definitions and Classifications, Indicated and Brake Horsepower; Thermodynamics of the Gas Engine; Theoretical Comparison of Various Types of Internal Combustion Engines; The Various Events of the Constant-Volume and Constant-Pressure Cycle as Modified by Practical Conditions; The Temperature Entropy Diagram Applied to the Gas Engine; Combustion; Gas-Engine Fuels, The Solid Fuels, Gas Producers; The Gas Engine Fuels—Liquid Fuels; Carbureters and Vaporizers; Gas-Engine Fuels,—The Gas Fuels; The Fuel Mixture,—Explosibility, Pressure and Temperature; The History of the Gas Engine; Modern Types of Internal Combustion Engines; Gas Engine Auxiliaries—Ignition, Mufflers and Starting Apparatus; Regulation of Internal Combustion Engines; The Estimation of Power of Gas Engines; Methods of Testing Internal Combustion Engines; The Performance of Gas Engines and Gas Producers; Cost of Installation and of Operation.

THE MODERN ASPHALT PAVEMENT. By Clifford Richardson, M.Am.Soc.C.E., *John Wiley & Sons, New York*, 1908. Second edition, revised and enlarged. Cloth, 6 by 9; ix + 629 p.; 42 illustrations. Price $3.

The methods adopted by the author for the presentation of his material make this book of value alike to the engineer, the contractor, the road commissioner and the taxpayer. The descriptions of how asphalt pavement is made will be readily understood by the lay reader, while the substance of those chapters—on the chemistry of asphalt and the technology of the industry—intended for the engineer and expert may be had from the summary at the end of each chapter.

Contents by chapter headings: The Foundation or Base; The Intermediate Course; The Mineral Aggregate; Filler or Dust; The Nature of the Hydro-carbons which Constitute the Native Bitumens; Characterization and Classification of the Native Bitumens; Differentiation and Characterization of the Native Bitumens; Petroleums; The Solid Bitumens.

PRACTICAL TESTING OF GAS AND GAS METERS. By C. H. Stone, B.S., M.S. *John Wiley & Sons, New York*, 1909. Cloth, 6 by 9; x + 337 p.; 51 illustrations. Price $3.50.

The author's work as chief inspector of gas for the Public Service Commission, Second District, New York, has enabled him to obtain valuable data on the subject treated. As the title indicates, the book deals with methods of testing rather than manufacture and distribution. The chemical processes and calculations have been explained at length so that they may be clear to the gas-works manager and others with no chemical training. The author makes such comments and suggestions as will be helpful in the choice of apparatus or process. So far as we know, American literature on this subject is confined to the volume before us.

Contents by chapters:The Photometer and Accessories; Standards and Burners; Candle-Power Tests of Coal and Water Gas, Using Candles as Standards; Photometric Work with other Standards and Gases; Interpretation of Results and Legal Requirements; Carbonic Acid and Sulphuretted Hydrogen; Total Sulphur; Other Impurities; The Analysis of Gas; The Junker and Boys Calorimeters; Other Instruments and Methods; Consideration of Results; Specific Gravity and Pressure; The Cubic Foot and Meter Prover; The Method of Testing Meters.

STEAM POWER PLANT ENGINEERING. By G. F. Gebhardt. *John Wiley & Sons, New York*, 1908. Cloth, 6 by 9, xxix + 816 p.; 461 illustrations. Price $6.

The book contains the substance of a series of lectures at the Armour Institute of Technology. The author devotes fully a third of the book to matters intimately connected with the coal pile. In the chapter on fuels, the use of oil as a fuel receives attention. Somewhat incomplete figures are given of the cost of boilers, stokers and chimneys. An analysis is given of the strains in a steel-concrete chimney. Considerable space is devoted to the apparatus of the power plant, including steam engines, turbines and auxiliaries, cost figures of which are given. Perhaps the chapter of greatest interest to engineers will be that on the cost of power. A very complete bibliography supplements the numerous references in the text.

Contents by chapter headings: Elementary Steam Power Plants; Fuels and Combustion; Boilers; Smoke Preventions, Furnaces, Stokers; Superheated Steam, Superheaters; Coal and Ash-Handling Apparatus; Chimneys; Mechanical Draft; Steam Engines; Steam Turbines; Condensers; Feed-Water Purifiers and Heaters; Pumps; Separators, Traps and Drains; Piping and Pipe Fittings; Lubricants and Lubrication; Finance and Economics—Cost of Power; Testing and Measuring Instruments; Typical Specifications; A Typical Steam Turbine Station; A Typical Isolated Station. Appendices: General Bibliography—Power Plant Engineering and Design; A. S. M. E. Rules for Conducting Boiler Trials, Code of 1899; A. S. M. E. Rules for Conducting Steam Engine Tests; Steam Tables; Equivalent Values of Mechanical and Electrical Units; Miscellaneous Conversion Tables.

REFRIGERATING MACHINES; COMPRESSION; ABSORPTION. By Gardner T. Voorhees, S.B. *Ice and Cold Storage Publishing Company, Ltd., London,* 1909. Cloth, 5 by 7½; 70 p.; 10 diagrams, 4 plates. Price 4*s*. 6*d*.

The book is a reprint of a paper read before the First International Congress of the Refrigerating Industries at Paris in 1908. Mr. Voorhees attended this congress as a delegate of the United States government and was also appointed Honorary Vice-President of the A. S. M. E. to represent the Society on the occasion. He has included in the reprint a broader treatment of the subject than would ordinarily be found in a book of this size, as must necessarily be the case to come within the limits of a paper. He has included data from his own practice to enable engineers readily to solve problems of capacity and economy of a compression or an absorption system, or of their combinations. A number of tables and charts are included.

ELECTRIC MOTORS. THEIR INSTALLATION, CONTROL, OPERATION AND MAINTENANCE. By Norman G. Meade. *McGraw Publishing Company, New York,* 1908. Cloth, 5 by 7; v + 159 p.; 126 illustrations. Price $1.

The treatment is somewhat elementary, and mathematics have been eliminated. The illustrations and diagrams with the text serve to explain the different types of motors and their operation.

Contents by chapter headings: Theory of Electric Motors; Classification of Electric Motors; Control and Auxiliary Apparatus; Motor-Generator Sets; Installation of Electric Motors; Operating Hints; Repairs; Tables and Formulæ.

ACCESSIONS TO THE LIBRARY

BOOKS

Akademischen Verein Hütte. "Hütte" Ingenieurs Taschenbuch. Ed. 20. Vol. 1–3. *Berlin, 1908.* Purchase.

American Institute of Architects. Proceedings of the 42d Annual Convention, 1908. January, 1909. *Washington, 1909.* Gift.

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American Society of Engineering Contractors. *Journal.* Vol. 1, June, 1909. *New York, 1909.* Gift.

Annual Library Index, 1908. *New York, 1909.* Purchase.

Anuario Estadistico de la Republica Oriental del Uruguay. Tomo I. 1907–08. *Montevideo, 1909.* Gift.

Automatic Screw Machines and Their Tools. By C. L. Goodrich and F. A. Stanley. *New York, Hill Pub. Co., 1909.* Gift of Publishers.

Bericht über das Studienjahr 1907–1908. Königliche Technische Hochschule zu München. *München, 1909.* Gift.

Best Type of Canal for Panama. (House Document No. 10, pt. 2.) *Washington, Government, 1909.* Gift.

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Cooper Union for the Advancement of Science and Art. First half-century. Fiftieth Annual Report, 1909. *New York, 1909.* Gift.

Design and Construction of Industrial Buildings. By H. F. Stimpson. Gift of C. W. Rice.

Efficiency Test of a Pumping Plant Used for Rice Irrigation. By W. B. Gregory. Gift of A. M. Lockett & Co.

Electrical Trades Association of the Pacific Coast. Report of the 7th Annual Meeting and Luncheon, 1909. *San Francisco, 1909.* Gift.

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Die Entwicklung der Dampfmaschine. By Conrad Matschoss. Vol. 1–2. *Berlin, J. Springer, 1908.* Purchase.

Feed Water Heaters as Purifiers. By J. C. W. Greth. Gift of W. B. Scaife & Sons Co.

Forest Fires in Massachusetts. By F. W. Rane, State Forester. *Boston, 1909.* Gift.

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Gesundheits-Ingenieur. Vol. 32–date. *Munich, 1909–date.* Subscription.

Grove City College. Catalogue, 1907–1908, and Courses of Study for 1908–1909. *Grove City, Pa., 1909.* Gift.

GUIDE TO CURRENT PERIODICALS AND SERIALS OF THE UNITED STATES AND CANADA, 1909. Compiled by H. O. Severance and C. H. Walsh. *Ann Arbor, Mich., 1908.* Purchase.

HALL OF FAME. By G. F. Kunz. *1908.* Gift of New York University.

HANDBUCH DES EISENBAHNMASCHINENWESENS. By L. R. von Stockert. Vol. 1–3. *Berlin, J. Springer, 1908.* Purchase.

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HYDROELECTRIC DEVELOPMENT AT BERRIEN SPRINGS, MICH., OF THE INDIANA AND MICHIGAN ELECTRIC COMPANY SYSTEM. Gift.

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INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE. Proceedings and Addresses, 3d Annual Convention. *Grand Rapids, 1908.* Gift.

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KING, WILLIAM F. Address and Biographical Sketch. *New York, 1909.* Gift of Merchants' Association of New York.

LAKE CHAMPLAIN TERCENTENARY, July 4–10, 1909. *Albany, 1909.* Gift of New York State Education Department.

LITTLE FALLS (N. Y.) PUBLIC WORKS BOARD. Fourteenth Annual Report of the Board of Public Works and the 21st Annual Report as Water Commissioner of the City of Little Falls. *1908.* Gift.

LOCK CANAL AT PANAMA. By J. R. FREEMAN. (House Document No. 10, pt. 3.) *Washington, Government, 1909.* Gift.

MASSACHUSETTS HIGHWAY COMMISSION. Report of the Massachusetts Highway Commission, with a bill consolidating and arranging the laws relating to motor vehicles. (House Document No. 1310.) Gift of Professor Hutton.

METAL CORROSION AND PROTECTION, REFERENCES TO BOOKS AND MAGAZINE ARTICLES. Ed. 2. *Pittsburg, Carnegie Library, 1909.* Gift.

METROPOLITAN WATER AND SEWERAGE BOARD OF BOSTON. Eighth Annual Report. *Boston, Wright & Potter Printing Co., 1909.* Gift of Metropolitan Water and Sewerage Board.

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MISSOURI ELECTRIC LIGHT, GAS AND STREET RAILWAY WATER WORKS ASSOCIATION. Proceedings of National Convention, 1909. *Springfield, Mo., 1909.* Gift of the Association.

NATIONAL ELECTRIC LIGHT ASSOCIATION. Thirty-first Convention. Vol. 1, 1908. *Chicago, 1908.* Gift.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION. Education of workers in the shoe industry. *1908.* (Bulletin No. 8.) Gift of Professor Hutton.

The Navy. December 1908-March 1909. *Washington, 1909.* Gift.

New York State Museum. (Bulletin No. 130.) *Albany, 1909.* Gift.

Practical Testing of Gas and Coal Meters. By C. H. Stone. *New York, J. Wiley & Sons, 1909.* Gift of Publishers.

Programm de Königlich Bayerischen Technischen Hochschule zu München, *1908–1909.* Ed. 3, March 1909. *München, 1909.* Gift.

Pulp Wood Consumption. 1908. *United States Bureau of Census, Washington, 1909.*

Railway Statistics of United States of America, for 1908. Prepared by Slason Thompson. *Chicago, R. R. Donnelly & Sons, 1909.* Gift.

Rochester Engineering Society. Catalogue of Works on Engineering and Allied Subjects in the Reynolds Library. *Rochester, 1909.* Gift of Rochester Engineering Society.

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Schiffskessel. By Walter Mentz. *München, 1907.* Purchase.

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Springfield (Mass.) Board of Water Commissioners. Thirty-fifth Annual Report. *Springfield, Mass., 1909.* Gift of Massachusetts Board of Water Commissioners.

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Subject List of Works on the Laws of Industrial Property in the Library of the Patent Office. *London, 1909.* Gift of Great Britain Patent Office.

U. S. Patent Office. Report of the Commissioner, Vol. 3., 1856. Vol. 1., 1857. *Washington, Government, 1857–58.* Gift.

Vorlesungen über Ingenieur-Wissenschaften. Vol. 1. By G. C. Mehrtens. *Leipzig, W. Engelmann, 1908.* Purchase.

Western Australia Geological Survey. Bulletin No. 32. *Perth, R. S. Sampson, 1908.* Gift.

Western Canada Railway Club. *Official Proceedings.* Vol. 1. No. 4. May, 1909. *Winnipeg, 1909.* Gift.

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Wisconsin Railroad Commission. Second Annual Report. *Madison, 1908.* Gift of Railroad Commission of Wisconsin.

Zeitschrift für die Gesamte Kälte-Industrie. Vol. 16–date. *Münich, 1909–date.* Subscription.

EXCHANGES

American Railway Association. Proceedings of Session, May 19, 1909. *New York, 1909.*

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American Society of Naval Engineers. List of Members, 1909. *Washington, 1909.*

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Engineers' Society of Western Pennsylvania. Charter, By-Laws, List of Members, 1909. *Pittsburg, 1909.*

Institution of Civil Engineers. *Minutes of Proceedings.* Vol. 175. *London, 1909.*

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TRADE PUBLICATIONS

Association of Licensed Automobile Manufacturers, *7 E. 42d St., New York.*

The Automobile as a Feeder of Civilization. By H. F. Cuntz, showing the growth of the automobile industry.

E. W. Bliss Co., *Brooklyn, N. Y.* Catalogue on steam turbines.

Boston Incandescent Lamp Co., *Danvers, Mass.* Economy of electric lamps.

The Bristol Co., *Waterbury, Conn.* Bulletin No. 104, May 1909; recording gauges for all commercial ranges of pressure and vacuum.

Edwin Burhorn, *71 Wall St., New York.* Costs, construction and tests of cooling towers. Catalogue of riveted pipes, flanges, fittings, etc., and of internally fired boilers.

Carrier Air Conditioning Co., of America, *39 Cortlandt St., New York.*

Catalogue of Refrigeration Plants, refrigerating machines, air washers, humidifiers.

Champion Rivet Co., *Cleveland, O.* Victor boiler, structural and ship rivets.

Coffin Valve Co., *Boston, Mass.* Sluice and gate valves; fire hydrant, check, air valves; electric valves; light and heavy pressure gate valves, ball bearing two-speed hoists, filter apparatus.

Joseph Dixon Crucible Co., *Jersey City, N. J.* Valuable graphite products and their use in commerce and industry.

Erie Foundry Co., *Erie, Pa.* Description of Erie mechanical stoker for boilers of 50 h.p. and above.

Thomas A. Ford Co., *New York.* Steam and water specialties as regulators, steam traps, reducing valves, pump governors, electric pump controllers, relief valves, fire hydrants.

Frick Company, *Waynesboro, Pa.* Catalogues of all styles of cooling devices; of traction engines, smoke stacks, water wagons, plowing engines, etc.; of Eclipse Corliss steam engines; of Eclipse patent triple-pipe brine cooler.

General Electric Co., *Schenectady, N. Y.* Bulletin No. 4394 C: belt-driven alternators; Bulletin No. 4661: aluminum lightning arresters for alternating current circuits; Bulletin No. 4662: Thomson recording wattmeters for switchboard service; Bulletin No. 4663: Multigap lightning arresters for alternating currents; Bulletin No. 4664: direct-connected engine-driven railway generators; Bulletin No. 4666: improved type "H" transformers; Bulletin No. 4668: G. E. 216A railway motor; Bulletin No. 4669: Curtis steam turbines for low pressure and mixed pressure; Bulletin No. 4670: gaskets and bell mouths for conduit wiring marine, railway car equipment and underground work; Bulletin No. 4672: electric drive for large printing presses; Bulletin No. 4673: Pittsburg, Harmony, Butler and New Castle 1200-volt D. C. Railway; Bulletin No. 4674: polyphase induction motors; Bulletin No. 4679: Type DLC commutating pole motor. Also folders on various products of the company, Index to their Bulletins, and price lists.

Isolawerke, *Oerlikon, Zürich.* Catalogue of special products in insulating materials for electric work.

Manistee Iron Works, *Manistee, Mich.* Catalogue of steam valveless duplex pump.

Mason Regulator Co., *Boston, Mass.* General catalogue No. 58: regulating appliances.

I. S. Morris Co., *Philadelphia, Pa.* Bulletin No. 1: detail construction and cross-sections of turbines and centrifugal pumps.

National Electric Lamp Association, *Cleveland, O.* Carbon, Gem, Tantalum and Tungsten incandescent lamps.

Nernst Lamp Co., *Pittsburg, Pa.* Catalogue No. 5, January 1907: Nernst lamps.

Niles-Bement-Pond Co., *New York.* Catalogue of cyclone high-speed chain hoists with self-lubricating bearings.

Northwestern Expanded Metal Co., *Chicago, Ill.* Information on cost data, precautions, tests, concrete formulæ, cost of steel and expanded metal useful in plans for concrete buildings.

Oesterlein Machine Co., *Cincinnati, O.* No. 20 and 34 Plain Milling Machines; No. 24 and 30 Universal Milling Machines; Universal Cutter and Tool Grinder No. 2.

P. Pryibil, *512–524 W. 41st St., New York.* Catalogues of woodworking and power transmitting machinery.

Railway List Co., *Chicago, Ill.* Monthly Official Railway List, May 1909. Vol. 28.

Reliance Electric & Engineering Co., *Cleveland, O.* Bulletin on the crank shaper.

Risdon-Alcott Co., *Mt. Holly, N. J.* Catalogue of turbine water-wheels, cylinder and register gate turbines and all makes of turbines.

Joseph T. Ryerson & Son, *Chicago, Ill.* Monthly journal for July 1909, descriptive of supplies of the company.

Shaw Electric Crane Co., *Muskegon, Mich.* Catalogue of electric cranes.

Standard Sanitary Mfg. Co., *Canada.* Notes on the decision in the suit of the Standard Sanitary Mfg. Co. vs. the Standard Ideal Co.

Underfeed Stoker Co. of America, *Chicago, Ill.* Publicity Magazine, July 1909, containing articles on Clyde Iron Works, etc.

United Electric Light & Power Co., *New York.* Light, May 1909, Vol. 3, No. 5: proper lighting of churches; electric signs in New York City; June 1909, Vol. 3, No. 6: installation of electric light in Paterno Castle; July 1909, Vol. 4, No. 7: electric rock drills, electric vacuum cleaners, decorative lighting at the Arion Club, New York.

Karl Vesterdahl & Co., *90 West St., New York.* Refrigerating machinery and diagrams of standard ice plants.

Whitlock Coil Pipe Co., *Hartford, Conn.* Catalogues of Automobile, Coil and Bend, Heater and Plumbers' Supply Departments.

Williamson Submarine Corporation, *Norfolk, Va.* Submarine Bulletin, May, 1909, Vol. 2, No. 1: Williamson submarine tube-caisson; July 1909: submarine tube-caissons at the Seattle Exposition and article by H. Abiff: Overcoming the Elements.

R. Wolf, *Magdeburg, Germany.* A 500–650 h.p. patent reciprocating steam engine.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up of members of the Society, and these are on file, with the names of other good men not members of the Society who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

073 Supervisor of labor for factory employing 500 men. Line machine tools. Location Ohio. Applicant must be specially qualified to handle all matters pertaining to the employment and efficiency of labor. Give full particulars regarding qualifications, stating experience in detail, especially during past five years; state age and education.

MEN AVAILABLE

277 Member, graduate M. I. T., nine years' experience in mechanical engineering instruction and practice, desires commercial engagement in or near Chicago, Strength of materials and testing a specialty.

278 Member, with fifteen years' experience, expert on gas engines, producers and furnaces, gasoline and oil engines, pumping machinery; both designer and superintendent. At present chief engineer of medium-sized shop. University graduate, best of references.

279 Junior, experienced in design of machines used in paper, rubber, food, chemical and allied industries; at present located in middle west, desires position in or near New York City.

280 Member, age 40, desires position as assistant superintendent or designer of special machinery. Has had experience with paper bag and envelope machinery, steam disinfecting and sterilizing apparatus. Nine years superintendent of large blower works, four years with largest manufacturers of power transmission apparatus.

281 Mechanical and civil engineer, technical graduate, energetic, aggressive and systematic, 16 years experience as designer, chief draftsman and engineer. Conversant with both mechanical and structural work. Desires responsible position with first-class firm in engineering or executive capacity.

282 Junior member, graduate mechanical engineer, at present draftsman for company manufacturing gasoline and electric autos and motor buggies; desires position with automobile concern which will yield experience in all branches of the business and offer opportunity for advancement. Experienced especially in automobile and electrical engineering. Can demonstrate and sell, design and superintend construction.

283 Electrical and mechanical engineer, Cornell graduate, age 32. Practical experience power plant and shop superintendence; electric and pneumatic power distribution; application of electricity in manufacturing plants; specification work and correspondence. Broad knowledge of general machinery; executive and business ability; highest endorsements.

284 Junior member, at present engaged with company operating blast furnaces, mines etc., familiar with manufacture of merchant pig iron, including Gayley Dry Blast, and all details entering into plant operation; can handle men and produce results.

285 Junior member would like position as instructor in mechanical engineering. Graduate M. I. T., taught in technical schools for over two years, and with experience in engineering practice.

286 Gas and power plant engineer open for an engagement (for two years). Salary $6000 per annum. Specialty, construction and reorganization.

287 Recent graduate Stevens Institute, desires to locate with concern engaged in manufacture of gas or steam engines, turbines, etc. Will start in foundry or shop.

288 Superintendent of blast furnaces and rolling mills of large Pennsylvania corporation, drafting, rolling-mill design and machinery sales. Experience covers twenty years.

289 Member, fifteen years' experience on engines, boilers, condensers, heaters, piping, and power plants. Has finished present construction work and desires engagement in New England with manufacturer or as representative on salary or commission. Age thirty-nine. First-class references.

290 Mechanical engineer, having large practical foundry and machine shop experience, as well as technical education, is open for temporary engagement to investigate and adjust complaints, superintend installations of machinery, or furnish reports on examination of machines, power and industrial plants.

291 Junior member, just returned from an extended trip of study and inspection of railroad and shop practice in Europe. Has had three years' practice in locomotive and gas engine constructions. Seeks foreign representation of some machine tool manufacturing company. Speaks German. Member of German Society of Engineers. Would consider a railroad position in operating or motive power department.

292 Massachusetts Institute of Technology course in mining and metallurgy, also mechanical engineering one year. Varied practical experience as draftsman, car designer, superintendent, manager, executive positions, in charge of buying, selling, works management and entire charge of business employing maximum of 700 men. Have patented about 50 inventions particularly relating to structural details of railroad cars.

293 Member, technical graduate, thirteen years' practical experience, drafting machine tools, cranes, etc., heavy-duty steam, gas and special heat-engine design, testing and operation, also operation of large A.C and D.C. power plants; desires position as chief engineer or designer for engine builder, or as master mechanic of large plant.

294 Sales engineer for special machinery or plant equipment. Broad executive and shop experience, accurate estimator. Competent to manage office or plants. Eastern states preferred.

295 Works manager or superintendent,thoroughly experienced in modern machine shop, foundry and manufacturing practice, office systems, etc. Successfully filled similar positions for fifteen years. Good organizer and can turn out high-grade work at low cost.

296 Mechanical engineer with six years' experience in industrial engineering, will be open for engagement about October 1. Desires position in or near New York City.

297 Graduate M. I. T., experience in shop, drafting and as mechanical engineer for large manufacturers of shoe machinery, including wide range of work on design of interchangeable machinery; experience in building extensions to factory, rearrangement of machinery, etc. Would like position of further responsibility either in engineering or manufacturing line. Some teaching experience.

298 Junior member, graduate in mechanical engineering, University of Illinois; competent to engage as factory manager, superintendent or chief engineer. Experience as instructor in charge of shops and mechanical engineering course.

299 Experienced superintendent modern shop and foundry. Qualified to take charge of production or full management. Technical and practical. Good organizer and executive.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ACKERMAN, Wm. S. (1891; 1895; 1899), Cons. Engr., Colt Bldg., Paterson, N. J.

ADAMS, Walter H. (Junior, 1908), Prof. Mech. Engrg., Imperial Pei-Yang Univ., Tientsin, China.

ARNOLD, George (1904), Cleveland Frog and Crossing Co., and *for mail,* 7108 Hough Ave., Cleveland, O.

BARY, Mark (Associate, 1903), care of M. F. Levy, 621 Symes Bldg., Denver, Colo.

BEECHER, J. F. (Associate, 1908), Draftsman, Pa. Steel Co., and *for mail,* 203 State St., Harrisburg, Pa.

BIGELOW, Charles H. (1904), with Chas. T. Main, 45 Milk St., Boston, Mass.

BLACK, Edward S. (1903), 1407 Ry. Exchange Bldg., Chicago, Ill.

BLUMGARDT, Isaac E. (Associate, 1908), Hotel Florence, Tarrytown, N. Y.

BRADSHAW, Grant D. (Junior, 1904), Cons. Engr., 77 Jackson Blvd., Chicago, Ill.

BRENDLINGER, Wm. B. (Associate, 1907), Mgr., Ingersoll-Rand Co., 1226 Farmers' Bank Bldg., Pittsburg, Pa.

BROOKS, Paul Raymond (Junior, 1905), Union Bag and Paper Co., Sandy Hill, N. Y.

BROWN, Donald S. (Junior, 1908), Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

BULKLEY, J. Norman (1902), Cons. Elec. Engr., Genl. Mining and Finance Corp., and *for mail,* P. O. Box 1242, Johannesburg, Transvaal, South Africa.

BURGOON, Charles Eli (1907), Asst. Inspecting Engr., Isthmian Canal Com., and 18 Iowa Circle, Washington, D. C.

CARACRISTI, Virginius Z. (1904; 1907), 2205 Hanover Ave., Richmond, Va.

CARSTENS, Alexander Bismarck (1906), Gen. Mgr., Cia Minera del Sur. S. A., Sola de Vega, and Mina San Pablo, Teojomulco, and *for mail,* Apartado Postal 74, Oaxaca, Mexico.

CHACE, William W. (1908), Mech. Engr., Cleveland Twist Drill Co., and *for mail,* 9716 Logan Court, Cleveland, O.

CHAMBERLAIN, George E. (1907), La Grange, Ill.

CHRISTIE, Alexander G. (Associate, 1907), Asst. Prof. Steam Engrg., Univ. of Wisconsin, and 1713 Monroe St., Madison, Wis.

CHURCH, Elihu C. (Junior, 1908), Siasconset, Nantucket Is., Mass.

CLEMENS, A. B. (1904), Prin., Sch. Mech. Engrg., Internatl. Corr. Schools, and 1003 Quincy Ave., Scranton, Pa.

COLVIN. Fred Herbert (1895; 1899), Assoc. Editor, Am. Machinist, 505 Pearl St., New York, N. Y., and *for mail,* 56 N. Maple Ave., East Orange, N. J.

CROSBY, William Wyman (1900; 1902), with F. W. Dean, Mill Engr. and Arch., Rm. 1112, 53 State St., Boston, and 41 Arlington Rd., Woburn, Mass.

DAVIS, Charles Ethen (1896), Genl. Mgr., Warner Gear Co., Muncie, Ind.

DECKER, Edward P. (1906), Engr., Kemiweld Can Co., and 79 Pingree Ave., Detroit, Mich.

DODDS, William B. (Junior, 1907), Cons. Light, Power and Ice Co., Joplin, Mo.

DOHERTY, Henry L. (1903), Pres., Denver Gas and Elec. Co., 60 Wall St., New York, N. Y.

DONNELLY, William T. (1903), Cons. Engr., 135 Broadway, New York, N. Y.

DOUD, Arthur T. (Junior, 1907), Mech. Engr., Hale-Kilburn Metal Co., Glenwood Ave. and 19th St., Philadelphia, and 6365 Sherman St., Germantown, Philadelphia, Pa.

DUNN, Charles (1897), Hanover, N. H.

ELDRED, Byron E. (1899; 1903), Pres., Commercial Research Co., 149 Broadway, New York, and Box 4, Tuckahoe, also Bronxville, N. Y.

ELVIN, Albert Geo. (1907), Asst. to V. P., Franklin Ry. Supply Co., 30 Church St., New York, N. Y.

FLETEMEYER, Louis H. (Junior, 1906), 1425 Salem St., Lafayette, Ind.

GAY, Harry (Associate, 1907), A. L. Drum & Co., 624 Am. Trust Bldg, and *for mail,* 7111 Princeton Ave., Chicago, Ill.

GERRISH, William H. (1901), Supt. Soft Fibre Dept., Columbian Rope Co., and *for mail,* Osborne House, Auburn, N. Y.

HAGERTY, Walter W. (Junior, 1905), P. O., Middletown, Orange Co., N. Y.

HEARNE, Robert J. (1907), Secy. and Treas., Durbrow & Hearne Mfg. Co., 12 Wooster St., and 46 E. 82d St., New York, N. Y.

HELVEY, Geo Stanley (Junior, 1904), Mgr. of Shops, Imperial Motor Car Co., and *for mail,* 303 N. 2d St., Hamilton, O.

HENRY, Geo. J., Jr. (1901), Ch. Engr., Pelton Water Wheel Co., Rm. 1099 Monadnock Bldg., and 3999 Clay St., San Francisco, Cal.

HERRICK, James A. (1880), Rm. 1603, 2 Rector St., New York, N. Y.

HERRON, James H. (1897; 1905), Mgr., Motch & Merryweather Mchy. Co. 1124 Farmers' Bank Bldg., Pittsburg, and Elmhurst Inn, Sewickley, Pa.

HIGGINS, Albert W. (Associate, 1906), Engr., Hill-Hupfel Engrg. Co., 30 Church St., New York, N. Y.

HILL, Thomas (1900), Cons. Engr., 2102 Jersey St., and 2102 Lawndale, Quincy, Ill.

HOLLMANN, Frederick W. (Junior, 1907), Asst. Mech. Engr., Carborundum Co., Niagara Falls, N. Y.

IRELAND, Mark L. (Junior, 1902), 1st. Lieut., Ordnance Dept., U. S. A., Watertown Arsenal, Watertown, Mass.

JAKOBSSON, Herman G. (1907), Ordnance Designer, Rm. 135, Bureau of Ordnance, War Dept., and 3 Stanley Apts., Harvard St., Washington, D. C.

JETT, Carter C. (Junior, 1902), 638 Oak Hill Ave., Youngstown, O.

JOHNSON, J. E., Jr. (1896; 1901), Genl. Supt., Thomas Div., Republic Iron and Steel Co., Thomas, Ala.

JONES, Jarrard E. (Junior, 1903), U. S. S. South Carolina, Cramp's Shipyard, Philadelphia, Pa.

JURGENSEN, Jess Christian (Associate, 1905), 29 W. 97th St., New York, N. Y.

KEELY, Royal R. (1901; 1907), Prof. Elec. Engrg., Nova Scotia Tech. College, Halifax, N. S.

KEMBLE, Parker H. (1908), 62 Montague St., Brooklyn, N. Y.

KENT, Wm. (1880), Manager, 1885–1888; V. P., 1888–1890; 326 Washington St., Sandusky, O.

KNOX, S. L. Griswold (1892; 1901), V. P. and Ch. Engr., Bucyrus Co., South Milwaukee, Wis.

LARNER, Chester W. (Associate, 1907), Hyd. Engr., Wellman-Seaver-Morgan Co., and *for mail*, 6915 Euclid Ave., Cleveland, O.

LATTA, Nisbet (Junior, 1902), Mill and Gas Eng. Dept., Allis-Chalmers Co.. West Allis, Wis.

LEE, Ralph A. (Junior, 1909), Asst. Bldg. Supt., with Walter Kidde, 140 Cedar St., New York, and *for mail*, 414 78th St., Brooklyn, N. Y.

LEE, Wm. F. (1907), 1111 E. Main St., Richmond, Va.

LELAND, Frederic H. (1907), Production Engr., 122 Elmwood Ave., Narberth, Pa.

LEWIS, Wm. Y. (1902), 20, Pennard Mansions, Shepherds Bush, London, W., England.

LILLIBRIDGE, Ray D. (Associate, 1907), Suite 20, 100 Broadway, and P. O. Box 824, New York, N. Y.

LOCKWOOD, Burns D. (1907), Asst. Ch. Engr., Pressed Steel Car Co., McKees Rock, and *for mail*, 444 Dawson Ave., Bellevue, Pa.

LYMAN, Elihu Root (Junior, 1904), Mech. Engr., U. S. Heater Co., and *for mail*, 934 Lafayette Blvd., Detroit, Mich.

MacINTIRE, Horace Jas. (Junior, 1907), Instr. Engrg. Dept., Harvard Univ., Cambridge, Mass.

MacLAUCHLAN, James H. (1907), Engr., Am. Cement Engrg. Co., Yorktown, Va.

MacPHERSON, James Day (1899), Ch. Engr., Adolphus Busch, Purchaser of Am. Diesel Eng. Co., and *for mail*, 3513 Halliday Ave., St. Louis, Mo.

MORGAN, Lewis Henry (1904; 1906), Nuthurst, Nantwich, Cheshire, England.

MORITZ, Albert (1905), Comdr. U. S. Navy, Ret., 723 E. 18th St., Brooklyn, N. Y.

NAYLOR, Chas. Wm. (1905), Ch. Engr., Marshall Field & Co., 83 State St., and *for mail*, 4429 Congress St., Chicago, Ill.

NEWCOMB, Chas. L., Jr. (Associate, 1908), Deane Steam Pump Co., and *for mail*, 57 Fairfield Ave., Holyoke, Mass.

NICKERSON, Ralph R. (Junior, 1907), 65 Otis St., East Cambridge, Mass.

NICKLIN, Ernest W. (1900; Associate, 1907), Diamond Specialty Co., and 421 Cadillac Ave., Detroit, Mich.

OSBOURN, Millard P. (Junior, 1901), Osbourn & Robinson, 320 Penna. Bldg., Philadelphia, Pa.

PEARSON, Walter Ambrose (1907), Asst. Genl. Mgr., Rio de Janeiro Tramway Lgt. and Power Co., Avenida Central 76, Rio de Janeiro, Brazil, South America.

PENNINGTON, James H. (1902), Mech. Engr., Supt. of Cons. and Power, Am. Smelting and Refining Co., Perth Amboy Plant, Maurer, and *for mail*, 1 Lewis St., Perth Amboy, N. J.

PINGER, Geo. C. (Junior, 1907), Driggs-Seabury Ordnance Corps, Sharon, Pa.

RENNER, Roland B. (Junior, 1906), 226 Buttles Ave., Columbus, O.

RUPP, Manning E. (Junior, 1909), Gatun, Canal Zone, C. A.

SARENGAPANI, T. S. (Junior, 1903), Head Draftsman P. W. D., Guntur Dist., Madras, India.

SAR VANT, Wilbur N. (Junior, 1907), 109 Halsey St., Newark, N. J.

SERGEANT, Chas. H. (1895), 625 W. 138th St., New York, N. Y.

SHENBERGER, Geo. H. (Junior, 1909), Cast Thread Fitting and Fdy. Co., Seneca Falls, N. Y.

SINCLAIR, Angus (1883), Editor and Publisher, 114 Liberty St., New York, N. Y., and *for mail*, Millburn, N. J.

SPRADO, Ralph (1900), 1604 San Antonio Ave., Alameda, Cal.

STOUGHTON, Edwin R. (Associate, 1907), The Charlevoix, Apt. 1107, Detroit, Mich.

STRATTON, H. F. (Junior, 1904), Sales Mgr., Elec. Controller & Mfg. Co., and *for mail*, Suite 7, 1523 E. Boulevard, St. Louis, Mo.

STROM, Carl A. (1905), Mgr., Rogers Wks., Am. Loco. Co., Paterson, N. J.

STURGESS, John (1901), Hyd. Engr., 9 Arch St., Akron, O.

SULLIVAN, Lucien N. (1903), Translator War Dept., Army War College, and *for mail*, 2207 1st St., N. W., Washington, D. C.

TADDIKEN, J. F., Jr. (Junior, 1907), Am. Beet Sugar Co., Chino, Cal.

TAKEO, Toshisuke (1908), Cons. Engr., Yoshinotani Coal Mining Co., Ltd., Genl. Mgr., Karatsu Iron Wks., Karatsu, Hizen, Japan.

TOWN, Frederic E. (1905), Otis Elevator Co., Keenan Bldg., Pittsburg, Pa.

VALENTINE, Warren P. (Junior, 1904), Gen. Delivery, Holyoke, Mass.

VOSE, Fred Hale (Junior, 1906), Mech. Engrg. Dept., Case Sch. of Applied Science, and *for mail*, 10521 Lee Ave., Cleveland, O.

WARG, Robert (1903), Natl. Blower Wks., 17th St. and St. Paul Ave., and 319 Farwell Ave., Milwaukee, Wis.

WARREN, Ambrose Gilmore (1907), Mech. Engr., J. W. Paxson Co., 1607 Mt. Vernon St., Philadelphia, Pa.

WATSON, George L. (Junior, 1905), P. O. Box 448, Dover, Del.

WOLDENBERG, Izydor (Junior, 1903), Ingersoll-Rand Co., m.b.H. Ferencz Jozsef Rakpart 1F, Budapest, Austria-Hungary.

WRIGHT, Reginald A. (1907), Ch. Draftsman, Phila. Coal and Iron Co., and *for mail*, 7 S. 6th St., Pottsville, Pa.

YARYCAN, Edward B. (Junior, 1903), Supt., Yaryan Naval Stores Co., Gulfport, Miss.

YATES, Richard Llewellyn (Junior, 1907), Ch. Draftsman, Waterwheel and Turbine Pump Dept., Platt Iron Wks. Co., and *for mail*, 108 Oxford Ave., Dayton, O.

DEATHS

GILDERSLEEVE, David H.
LANDSING, Jang.
REED, Wm. T.

NEW MEMBERS

AHLQUIST, Harold (1909), Designing Engr., Solvay Process Co., Syracuse, N. Y.

BAENDER, Fred Geo. (Junior, 1909), Mech. Engr., P. O. Box 735, Spokane, Wash.

BLAISDELL, Benjamin H. (1909), Ch. Engr. and Supt., Manilla Elec. R. R. and Light Co., P. O. Box 451, Manila, P. I.

BLANCHARD, Arthur S. (Associate, 1909), Asst. to Mgr., Atha Steel Casting Co., Newark, and *for mail,* 25 Hampton Terrace, East Orange, N. J.

BLEYER, Chas. F. (Junior, 1909), Erecting Engr., Allis-Chalmers Co., Elyria, and *for mail,* 836 Cass St., Milwaukee, Wis.

BURT, Clayton R. (1909), Genl. Supt., Barber-Colman Co., 523 Fisher Ave., Rockford, Ill.

CASTLE, Samuel Northrup (Associate, 1909), Genl. Elec. Co., 30 Church St., New York, N. Y.

CLANCY, Geo. W. A. (Associate, 1909), Shop Insp., New Haven System, Readville, Mass.

FULLER, Ray W. (Associate, 1909), Supt., Scranton Stove Wks., Scranton, Pa.

GARVIN, George K. (1909), Pres., Garvin Mch. Co., Spring and Varick Sts., New York, N. Y.

JENKS, Glen F. (Junior, 1909), Capt. Ordnance Dept., U. S. A., Frankford Arsenal, Philadelphia, Pa.

MAYALL, E. L. (1909), Genl. Supt., Rock Island Plow Co., and 1003 2d Ave., Rock Island, Ill.

MORAT, Jacques (1909), Spuyten Duyvil, N. Y.

NICHOLL, John Seymour (Junior, 1909), Acting Mgr., F. W. Horne, Importer Am. Mchy., 70-C, Yokohama, Japan.

OTTO, Henry S. (Junior, 1909), Messrs. Munroe & Co., rue Scribe 7, Paris, France.

PINNER, Seymour Wm. (Junior, 1909), Instr., Univ. of Michigan, and *for mail,* 608 E. Madison St., Ann Arbor, Mich.

RUPP, Manning E. (Junior, 1909), Computer-Estimator, Isthmian Canal Com., Culebra, Canal Zone, C. A.

SHAW, James C. (1909), Engr. and Tech. Adviser, Kawasaki Dockyard Co., Ltd., Kobe, Japan.

SHIELDS, George Rex (Associate, 1909), Engr., Improved Equipment Co., 60 Wall St., New York, N. Y.

STACKS, H. Roy (1909), Supt., Geo. V. Cresson Co., 18th and Allegheny Ave., Philadelphia, Pa.

STEWART, Chas. E. (Junior, 1908), Asst. Prof. of Mechanic Arts, Tufts College, Tufts College P. O., Mass.

TOBIN, Robert P. (1909), Ch. Tech. Dept., Vacuum Oil Co., 49 Federal St., Boston, Mass.

WATERS, William L. (1909), Designing Engr., Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

WELLS, Robert G. (1909), Genl. Mgr., Tata Iron and Steel Co. Ltd., Sakchi, via Kalimati, B. N. Ry., India.

WICKS, H. B. Priestley (Junior, 1908), Genl. Mgr. Elec. Dept., Scott Bros. Ltd., and *for mail,* 21 Graffon St., Linwood, Christchurch, New Zealand.

PROMOTIONS

BIBBINS, James Rowland (1904; 1909), Engr. Appraisal Bureau, Public Service Com., 1912 Tribune Bldg., New York, N. Y.

COOKE, Morris Llewellyn (1903; 1909), Cons. Engr., 401 W. Walnut Lane, Germantown, Philadelphia, Pa.

DAVOUD, Vahram Y. (1906; Associate, 1909), Elec. Engr., Telluride Power Co., Provo, Utah, and Univ. Club, Buffalo, N. Y.

GROVER, Marcus A. (1903; 1909), Cons. Engr., Box 590, Birmingham, Ala.

GAS POWER SECTION

CHANGES OF ADDRESS

BIBBINS, James Rowland (1908), Engr., Appraisal Bureau, Pub. Service Com., 1912 Tribune Bldg., New York, N. Y.

DOHERTY, Henry L. (1908), Pres., Denver Gas and Elec. Co., 60 Wall St., New York, N. Y.

HASBROUCK, Stephen A. (Affiliate, 1909), Cons. Mech. Engr., 161 Lexington Ave., New York, N. Y.

LATTA, Nisbet (1908), Mill and Gas Engrg. Dept., Allis-Chalmers Co., West Allis, Wis.

MACPHERSON, James Day (1908), Ch. Engr., Adolphus Busch, Purchaser of Am. Diesel Eng. Co., and *for mail* 3513 Halliday Ave., St. Louis, Mo.

MONAHAN, Louis J. (Affiliate, 1908), V. P., Supt. and Mech. Engr., Termaat & Monahan Co., and 57 Waugoo St., Oshkosh, Wis.

SAGE, Darrow (Affiliate, 1908), Hudson & Manhattan R. R. P.H., 1st and Washington Sts., Jersey City, N. J.

VOSE, Fred Hale (1909), Mech. Engrg. Dept., Case Sch. of Applied Science, and *for mail*, 10521 Lee Ave., Cleveland, O.

NEW MEMBERS

ADAMS, Edward T., (1909), Mgr. and Ch. Engr., Gas and Mill Eng. Dept., Allis-Chalmers Co., Milwaukee, Wis.

ANDERSON, Harry Warfield (1909), Genl. Mgr., White Star Auto Co., and *for mail*, No. 6, Lenox Apts., 31 Porter Pl., Atlanta, Ga.

BAENDER, Fred Geo. (1909), Mech. Engr., P. O. Box 735, Spokane, Wash.

BREW, William P. (Affiliate, 1909), Commercial Engr., Westinghouse Mch. Co., 165 Broadway, New York, N. Y.

CHASE, Leon Wilson (1909), Prof. Farm Mechanics, Univ. of Neb., and 1245 N. 33d St., Lincoln, Neb.

COLLETT, S. D. (1909), V. P. and Eastern Mgr., Elev. Supply and Repair Co., 114–116 Liberty St., New York, N. Y.

CUMMINGS, Wm. Warren (1909), Asst. Mgr., Commercial Dept., Boston Cons. Gas. Co , 24 West St., Boston, and *for mail*, 15 Winter St., Woburn, Mass.

FISH, Walter C. (Affiliate, 1909), Mgr. Lynn Wks., Gen. Elec. Co., and 21 Wave St., Lynn, Mass.

FLEMING, Wills Maine (1909), Engr. in charge Drawing Room, Deane Branch, Internatl. Steam Pump Co., and *for mail*, 370 Cabot St., Holyoke, Mass.

GROVER, Marcus A. (1909, Cons. Engr., Box 590, Birmingham, Ala.

HALE, Frederick J. (1909), Eng. Dept., Westinghouse Mch. Co., East Pittsburg, and *for mail*, 1133 Franklin Ave., Wilkinsburg, Pa.

HAMILTON, Clinton A. (1909), Genl. Mgr. and V.P., Wisconsin Eng. Co., and *for mail,* 1033 Lake Ave., Racine, Wis.

HERRICK, James A. (1909), Rm. 1603, 2 Rector St., New York, N. Y.

HOWELLS, Charles (1909), Supt., Watson-Stillman Co., 50 Church St., and *for mail,* 600 W. 142d St., New York, N. Y.

LATHAM, Harry M. (1909), Mech. Engr., Am. Steel & Wire Co., and *for mail,* 94 Grove St., Worcester, Mass.

LEE, Francis V. T. (1909), Asst. Genl. Mgr., Pacific Gas & Elec. Co., 445 Sutter St., San Francisco, and *for mail,* 59th St., E. of College Ave., Oakland, Cal.

MICHEL, Arthur Eugene (1909), Adv. Engr., 1572 Hudson Terminal Bldg., New York, N. Y.

MOORE, Allen H. (1909), Genl. Elec. Co., and *for mail,* 352 Western Ave., Albany, N. Y.

OULD, John Geo. (1909), Supt. and Ch. Engr., Polhemus Memorial Clinic., Brooklyn, N. Y.

PATITZ, J. F. Max (1909), Cons. Mech. Engr., Allis-Chalmers Co.; and *for mail,* 473 38th St., Milwaukee, Wis.

RICE, George W. (1909), Engrg. Dept., Olds Gas Power Co., and *for mail,* 513 Sparrow Ave., Lansing, Mich.

ROTH, Charles (Affiliate, 1909), Mech. Engr., Liquid Carbonic Co., Wells and Mich. Sts., Chicago, Ill.

SAMPSON, Chas. C. (Affiliate, 1909), Inspr. Gas Power Mchy., Ill. Steel Co., South Chicago, and *for mail,* 1475 E. 73d St., Chicago, Ill.

SCOFIELD, Edward H. (Affiliate, 1909), Engr. and Power Equip., Twin City Rapid Transit Co., and 3313 Lyndale Ave., S., Minneapolis, Minn.

SIMONS, Joseph Aiken (Affiliate, 1909), Mech. Engr., E. I. du Pont de Nemours Powder Co., 607 du Pont Bldg., Wilmington, Del.

SPRADO, Carl G. (1909), Engr. and Ch. Draftsman, Gas and Mill Eng. Dept., Allis-Chalmers Co., and *for mail,* 752 29th St., Milwaukee, Wis.

TROUT, Geo. Henry (Affiliate, 1909), Sales Mgr., Smith Gas Power Co., Lexington, O.

VAIL, Jesse A. (1909), Genl. Mgr., Fairbanks, Morse Mfg. Co., Beloit, Wis.

VINCENT, Jay Carter (Affiliate, 1909), Asst. Engr. Power and Equip., Twin City Rapid Transit Co., Minneapolis, Minn.

DEATHS

GILDERSLEEVE, David H.

STUDENT SECTION

CHANGES OF ADDRESS

BECKMANN, Harry T. (Student, 1909), 2475 Collingwood Ave., Toledo, O.
BROOKMAN, H. D. (Student, 1909), 511 Riverside Ave., Wellsville, O.
COYLE, J. F. (Student, 1909), 1311 Fones Ave., St. Joseph, Mich.
FINCH, Ellis J. (Student, 1909), 260 W. 136th St., New York.
FREYGANG, Gustav G. (Student, 1909), Engrg. Dept., Natl. Elec. Lamp Asso., 4411 Hough Ave., Cleveland, O.
HANDY, Robert G. (Student, 1909), 625 University Ave., Ithaca, N. Y.
HOLLENBERGER, Theo. J. (Student, 1909), 2564 N. Paulina St., Chicago, Ill.
LAWRENCE, John H. (Student, 1909), 13 Grove Pl., Albany, N. Y.
LOCKARD, J. P. (Student, 1909), 26 Church St., Plymouth, Pa.
LUSE, F. D. (Student, 1909), 973 E. 9th St., N., Portland, Ore.
MUDD, John Posey (Student, 1909), 415 Clinton Ave., Rochester, N. Y.
PAGE, W. K. (Student, 1909), Olean, N. Y.
PARCE, Donald H. (Student, 1909), 2614 Waring St., Berkeley, Cal.
RICHARDSON, L., Jr. (Student, 1909), 1018 Lexington Ave., Altoona, Pa.
ROSCOE, A. P. (Student, 1909), Oakley Ave., Ozone Park, L. I., N. Y.
SAWERS, Edward H. (Student, 1909), 548 Lake Ave., Rochester, N. Y.
SCHICKEL, Norbert H. (Student, 1909), 52 E. 83d St., New York.
STEWART, Arthur L. (Student, 1909), 42 Prince St., Rochester, N. Y.
SYMES, W. H. (Student, 1909), 326 W. Church St., Marion, O.
WILSON, Joseph S. (Student, 1909), 404 S. Clayton St., Wilmington, Del.

NEW MEMBERS

KELLOG, E. N. (Student, 1909), Vineland, N. J.
VAIL, A. G. (Student, 1909), Milton-on-the-Hudson, N. Y.
VAN ETTEN, Percy H. (Student, 1909), 465 Hawthorne Ave., Palo Alto, Cal.
ZIMMERMAN, Peter C. (Student, 1909), State Agr. College of Ore., Corvallis, Ore.

COMING MEETINGS

September and October

Secretaries or members of societies whose meetings are of interest to engineers are invited to send in their notices for publication in this department. Such notices should be in the editor's hands by the 15th of the month preceding the meeting.

AMERICAN GAS INSTITUTE

October 20–22, Hotel Pontchartrain, Detroit, Mich. Secy., A. B. Beadle, 25 West 39th St., N. Y.

AMERICAN INSTITUTE OF MINING ENGINEERS

September 27–29, Spokane, Wash. Papers: Dust Explosions; Modern Progress in Mining and Metallurgy; Ventilating System of the Comstock Mines; Professional Ethics; Ruble Hydraulic Elevator; etc. Acting Secy., Joseph Struthers.

AMERICAN MINING CONGRESS

September 27–October 2, Goldfield, Neb. Secy., J. F. Callbreath, Jr., Denver, Colo.

AMERICAN PUBLIC HEALTH ASSOCIATION

October, Richmond, Va. Secy., C. O. Probst, Columbus, O.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION

October 19–21, annual convention, Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine Ry., Concord, N. H.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

October 12, monthly meeting, 29 W. 39th St., New York. September 11, St. Louis, Mo. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION

October 4–8, annual convention, Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York.

ASSOCIATION OF CAR LIGHTING ENGINEERS

October 5–8, annual convention, Chicago, Ill. Secy., G. B. Colegrove, 6250 Drexel Ave., Chicago, Ill.

CANADIAN MANUFACTURERS ASSOCIATION

September 14–16, annual meeting, Hamilton, Can.

CENTRAL ASSOCIATION OF RAILROAD OFFICERS

September 22–24, annual meeting, Cincinnati, O. Genl. Secy., O. G. Felter, Carew Bldg.

CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA

September 21, October 19, Prince George Hotel, Toronto, Ont. Papers: Filling and Washing out of Boilers, J. V. Jackson; Care and Maintenance of Elevators, J. Shales. Secy., C. L. Worth, Union Sta., Toronto.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION

October 7–9, annual convention, Denver, Colo. Papers: The Commercial

Field; Meters and Testing; Lamps and Illumination. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS

September 14–16, annual convention, Atlantic City, N. J. Secy., Frank P. Foster, Corning, N. Y.

KANSAS GAS, WATER, ELECTRIC LIGHT AND STREET RAILWAY ASSO.

September 23–24, Wichita. Secy., J. D. Nicholson, Newton.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

September 13–18, Columbus, O. Secy., F. W. Raven, 325 Dearborn St., Chicago, Ill.

NEW ENGLAND WATER WORKS ASSOCIATION

September 8–10, annual convention, New York. Secy., Willard Kent, 715 Tremont Temple, Boston, Mass.

NOVA SCOTIA SOCIETY OF ENGINEERS

September 9–10, annual convention, New Glasgow. Secy., S. Fenn, Halifax.

PACIFIC COAST GAS ASSOCIATION

September 21–23, San Francisco, Cal. Secy., John A. Britton, 925 Franklin St.

PENNSYLVANIA ELECTRIC ASSOCIATION

September 8–10, annual convention, Eagles Mere, Pa. Pres., L. H. Conklin, Scranton.

RAILWAY SIGNAL ASSOCIATION

October 12–14, Louisville, Ky. Secy., C. C. Rosenberg, 712 North Linden St., Bethlehem, Pa.

ROADMASTERS AND MAINTENANCE OF WAY ASSOCIATION

September 14–17, annual convention, Washington, D. C. Paper: Treated Ties, J. M. Meade. Secy., W. E. Emery, P. & P.U. Ry., Peoria, Ill.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA

October 5–7, Toronto. Secy., Alcide Chausse, R.S.A., P. O. Box 259, Montreal, Que.

TEXAS RAILWAY CLUB

September 20, semi-annual meeting. Secy., T. H. Osborne, Pine Bluff, Ark.

TRAVELING ENGINEERS' ASSOCIATION

September 7–10, annual convention, Albany Hotel, Denver, Colo. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

WESTERN ASSOCIATION OF ELECTRICAL INSPECTORS

October 26–28, annual meeting, Detroit, Mich.

MEETINGS TO BE HELD IN ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
September			
1	Wireless Institute	S. L. Williams	7.30
2	Blue Room Engineering Society	W. D. Sprague	8.00
3	Explorers' Club	H. C. Walsh	8.30
4	Amer. Soc. Hungarian Engrs. and Archts.	Z. deNemeth	8.30
7	N. Y. Society Accountants and Bkprs.	T. L. Woolhouse	8.00
8	Optometrical Society of City of N. Y.	J. H. Drakeford	8.00
9	Illuminating Engineering Society	P. S. Millar	8.00
10	American Institute Electrical Engrs.	R. W. Pope	8.00

14	N. Y. Soc. Accountants and Bkprs	T. L. Woolhouse	8.00
17	New York Railroad Club	H. D. Vought	8.15
21	N. Y. Soc. Accountants and Bkprs	T. L. Woolhouse	8.00
22	Municipal Engineers of City of N. Y	C. D. Pollock	8.15
27–29	Illuminating Engineering Society	P. S. Millar	All day
28	N. Y. Society Accountants and Bkprs	T. L. Woolhouse	8.00
28–30	Amer. Electro-Therapeutic Asso	A. C. Geyser	All day
October			
1	Explorers' Club	H. C. Walsh	8.30
2	Amer. Soc. Hungarian Engrs. & Archts	Z. deNemeth	8.30
5	N. Y. Soc. Accountants and Bkprs	T. L. Woolhouse	8.00
6	Wireless Institute	S. L. Williams	7.30
7	Blue Room Engineering Society	W. D. Sprague	8.00
8	American Institute Electrical Engrs	R. W. Pope	8.00
12	N. Y. Soc. Accountants and Bkprs	T. L. Woolhouse	8.00
12	The American Society of Mech. Engrs	C. W. Rice	8.00
13	Optometrical Society of City of N. Y	J. H. Drakeford	8.00
14	Illuminating Engineering Society	P. S. Millar	8.00
15	New York Railroad Club	H. D. Vought	8.15
19	New York Telephone Society	T. H. Lawrence	8.00
19	N. Y. Society Accountants and Bkprs	T. L. Woolhouse	8.00
26	N. Y. Society Accountants and Bkprs	T. L. Woolhounse	8.00
27	Municipal Engineers of City of New York	C. D. Pollock	8.15

OFFICERS AND COUNCIL

PRESIDENT

Jesse M. Smith	New York

VICE-PRESIDENTS

L. P. Breckenridge	Urbana, Ill.
Fred J. Miller	Center Bridge, Pa.
Arthur West	E. Pittsburg, Pa.

Terms expire at Annual Meeting of 1909

Geo. M. Bond	Hartford, Conn.
R. C. Carpenter	Ithaca, N. Y.
F. M. Whyte	New York

Terms expire at Annual Meeting of 1910

PAST PRESIDENTS

Members of the Council for 1909

Ambrose Swasey	Cleveland, O.
John R. Freeman	Providence, R. I.
Frederick W. Taylor	Philadelphia, Pa.
F. R. Hutton	New York
M. L. Holman	St. Louis, Mo.

MANAGERS

G. M. Basford	New York
A. J. Caldwell	Newburg, N. Y.
A. L. Riker	Bridgeport, Conn.

Terms expire at Annual Meeting of 1909

Wm. L. Abbott	Chicago, Ill.
Alex. C. Humphreys	New York.
Henry G. Stott	New Rochelle, N. Y.

Terms expire at Annual Meeting of 1910

H. L. Gantt	Pawtucket, R. I.
I. E. Moultrop	Boston, Mass.
W. J. Sando	Milwaukee, Wis.

Terms expire at Annual Meeting of 1911

TREASURER

William H. Wiley	New York

HONORARY SECRETARY

F. R. Hutton	New York

CHAIRMAN OF THE FINANCE COMMITTEE

Arthur M. Waitt	New York

SECRETARY

Calvin W. Rice	29 W. 39th Street, New York

EXECUTIVE COMMITTEE OF THE COUNCIL

Jesse M. Smith, *Chairman*
F. R. Hutton
Alex. C. Humphreys
Fred J. Miller
F. M. Whyte

STANDING COMMITTEES

FINANCE

Arthur M. Waitt (1), *Chairman*
Geo. J. Roberts (3)
Edward F. Schnuck (2)
Robert M. Dixon (4)
Waldo H. Marshall (5)

HOUSE

Henry S. Loud (1) *Chairman*
Bernard V. Swenson (3)
William Carter Dickerman (2)
Francis Blossom (4)
Edward Van Winkle (5)

LIBRARY

John W. Lieb, Jr. (4), *Chairman*
Ambrose Swasey (2)
H. H. Suplee (1)
Leonard Waldo (3)
Chas. L. Clarke (5)

MEETINGS

Willis E. Hall (1), *Chairman*
L. R. Pomeroy (3)
Wm. H. Bryan (2)
Charles E. Lucke (4)
H. de B. Parsons (5)

MEMBERSHIP

Henry D. Hibbard (1), *Chairman*
Francis H. Stillman (3)
Charles R. Richards (2)
George J. Foran (4)
Hosea Webster (5)

PUBLICATION

Arthur L. Williston (1), *Chairman*
H. F. J. Porter (3)
D. S. Jacobus (2)
H. W. Spangler (4)
Geo. I. Rockwood (5)

RESEARCH

W. F. M. Goss (5), *Chairman*
R. C. Carpenter (2)
Jas. Christie (1)
R. H. Rice (3)
Chas. B. Dudley (4)

Note.—Numbers in parentheses indicate length of term in years that the member has yet to serve.

SPECIAL COMMITTEES
1909

On a Standard Tonnage Basis for Refrigeration

D. S. Jacobus
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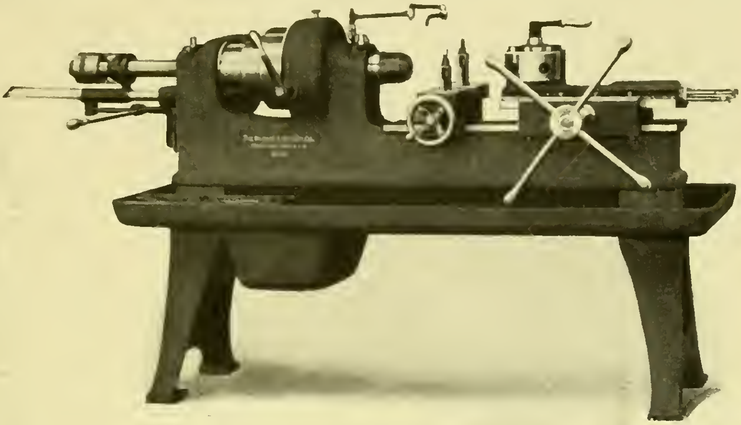

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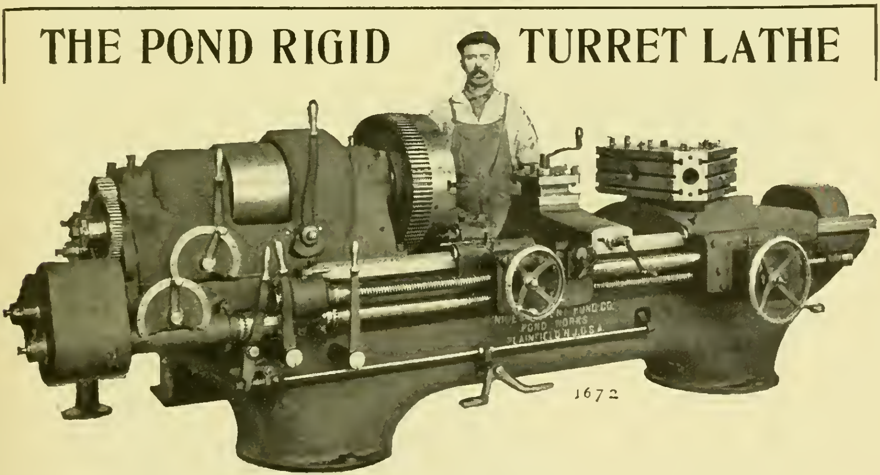

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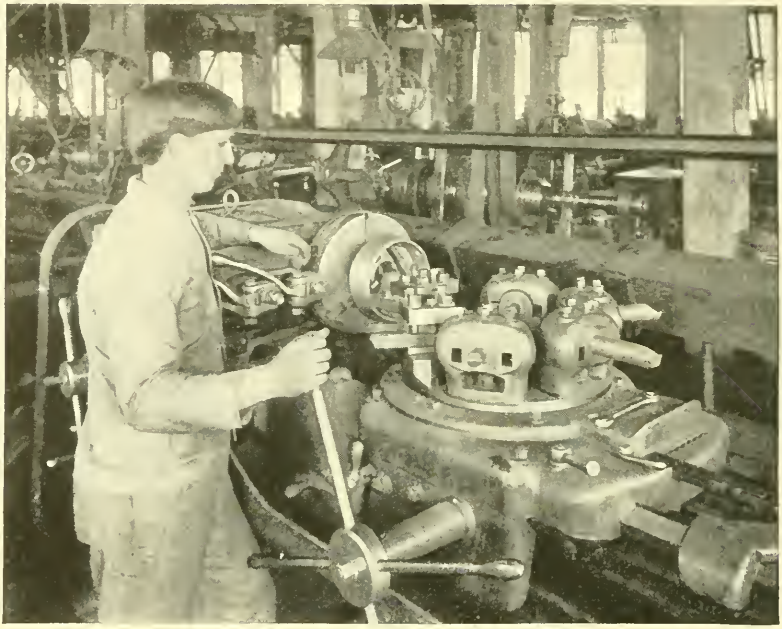

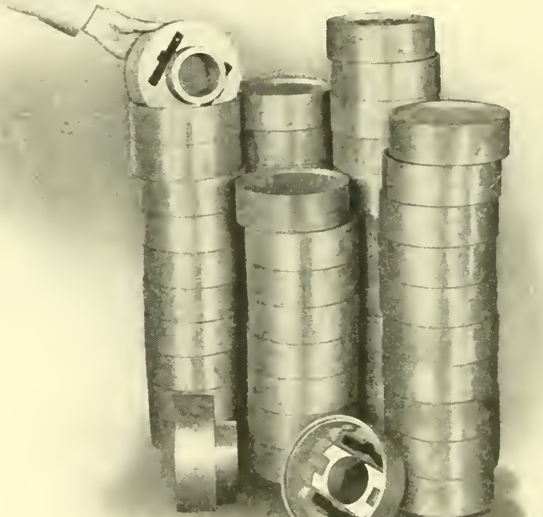

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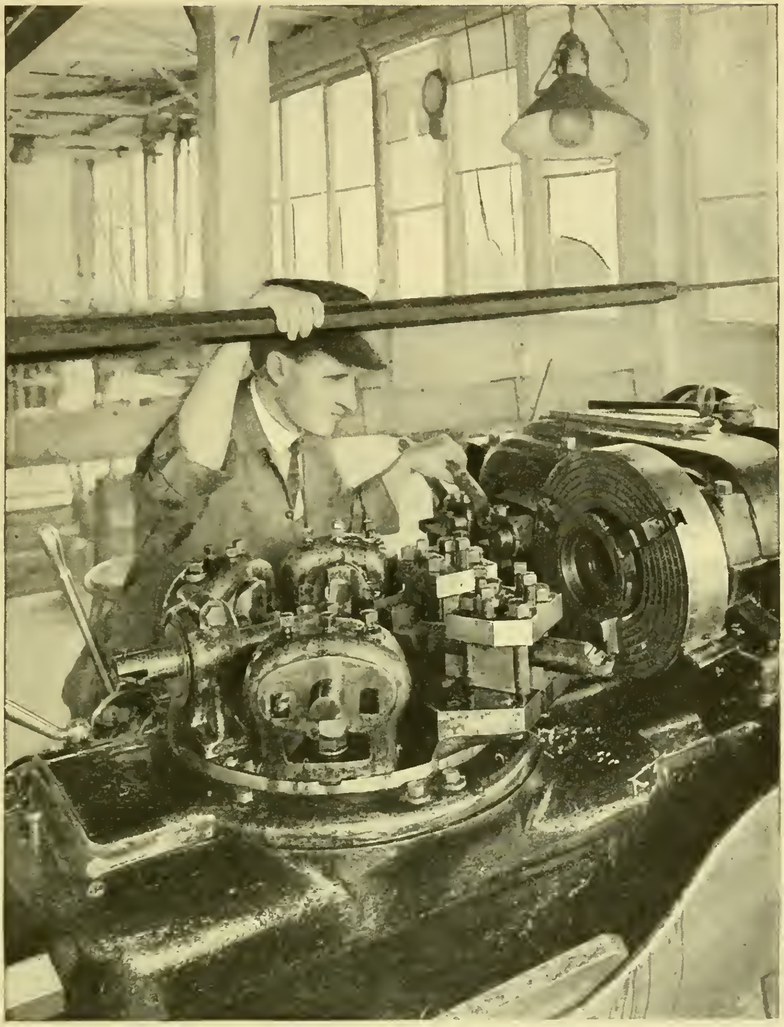

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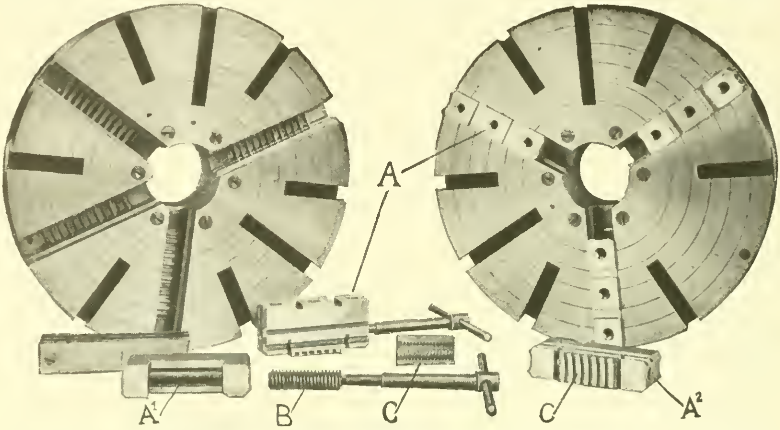

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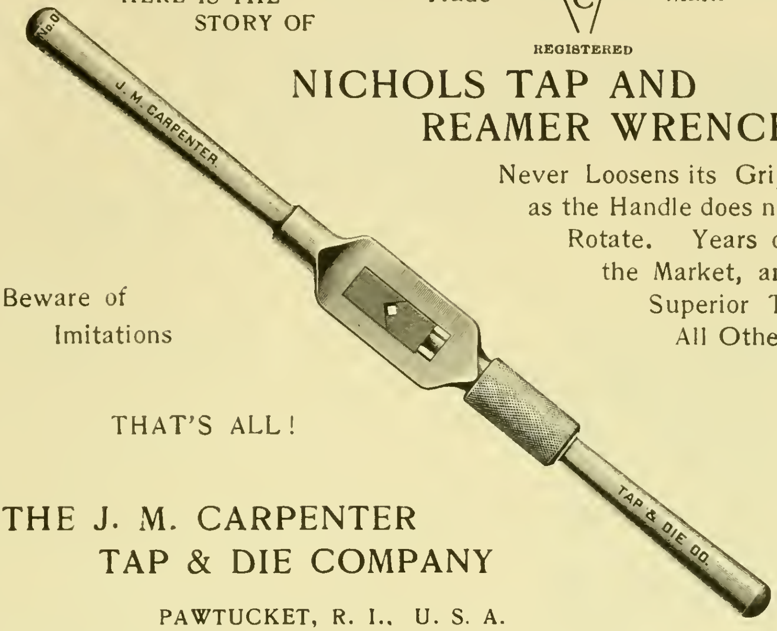

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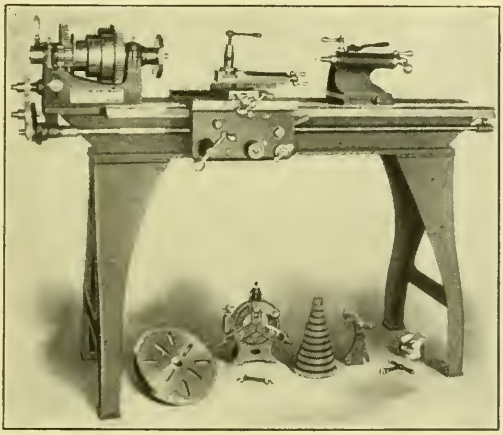

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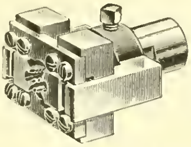

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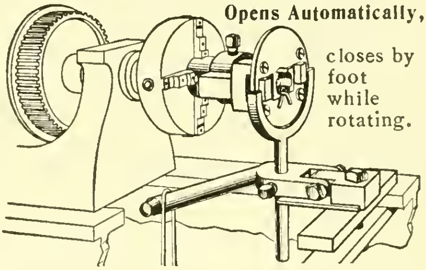

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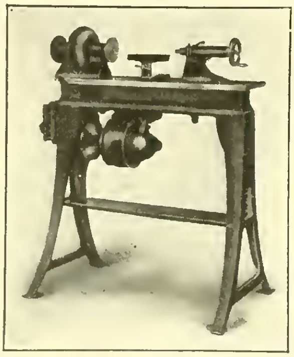

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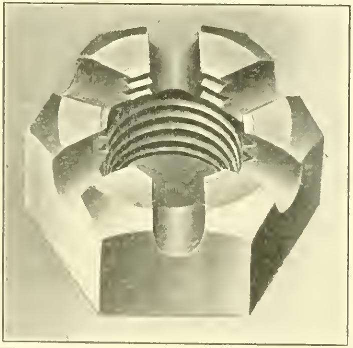

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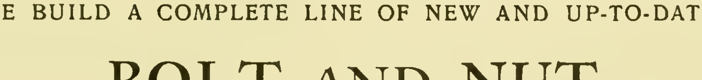

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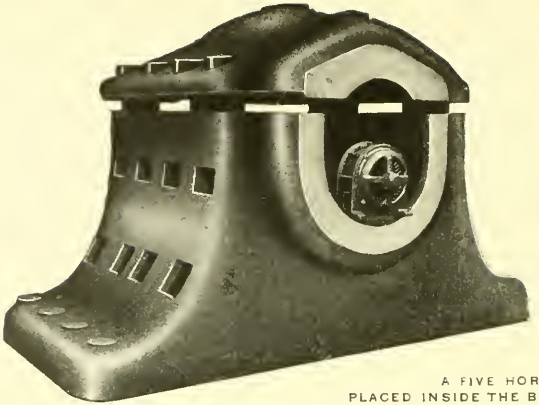

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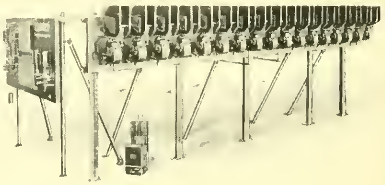

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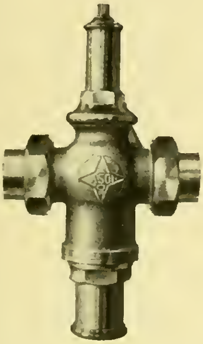

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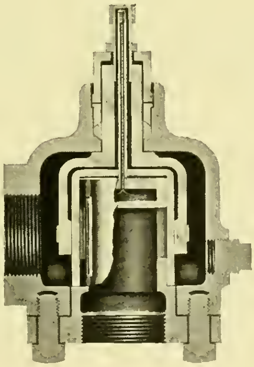

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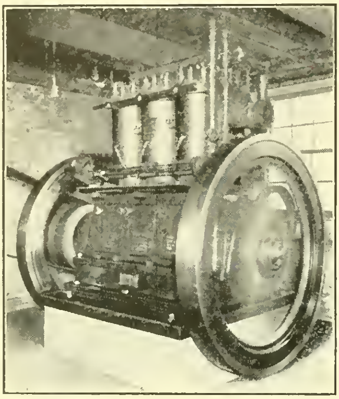

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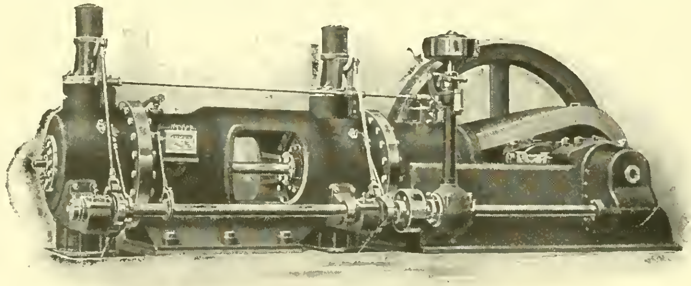

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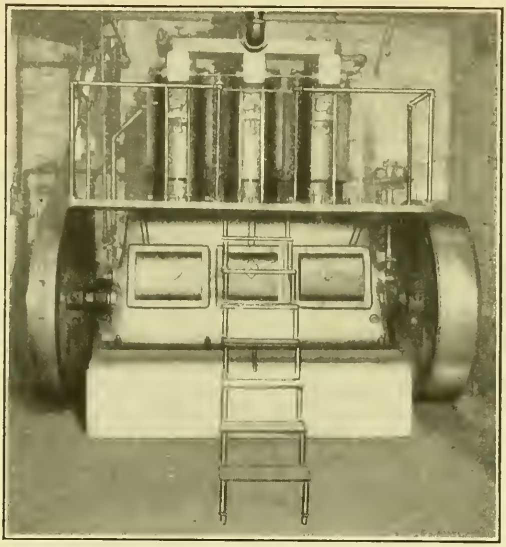

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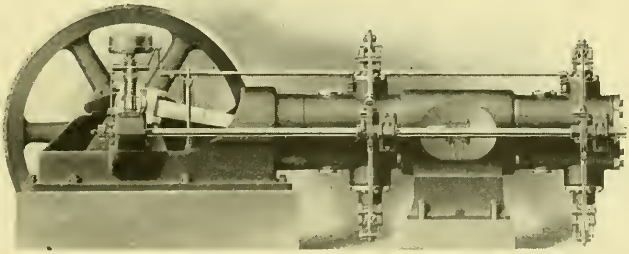

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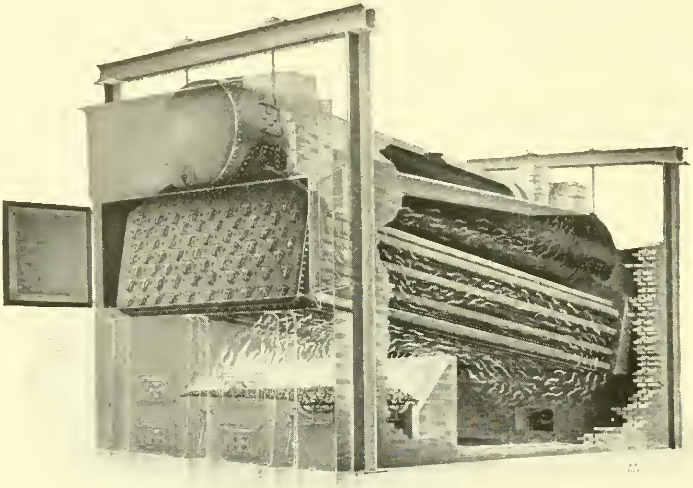

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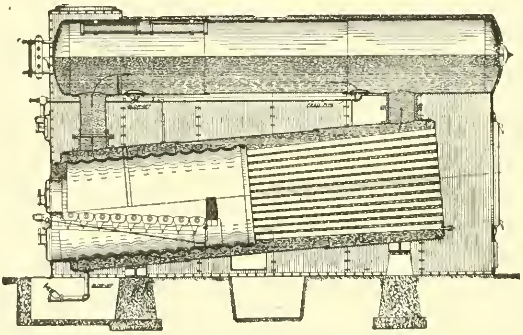

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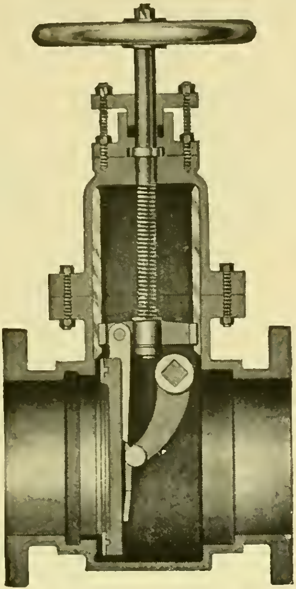

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It gives us great pleasure to testify to the merit of your Valve for the service described.

Very respectfully,
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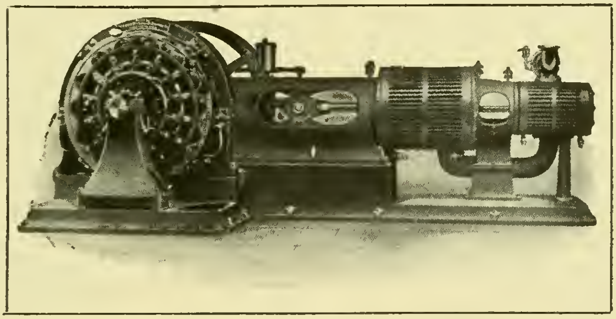
WALCH & WYETH, 87 Lake St. Chicago



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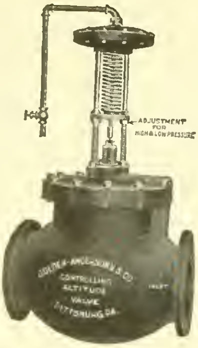
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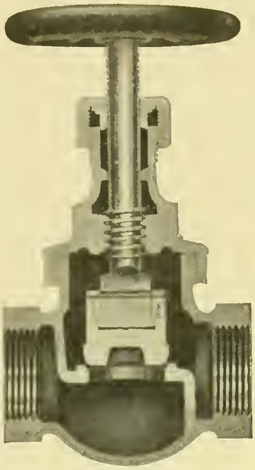

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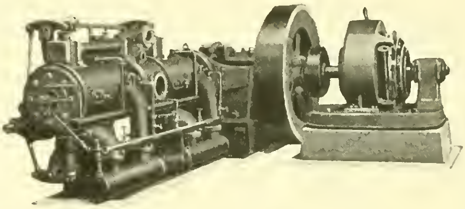

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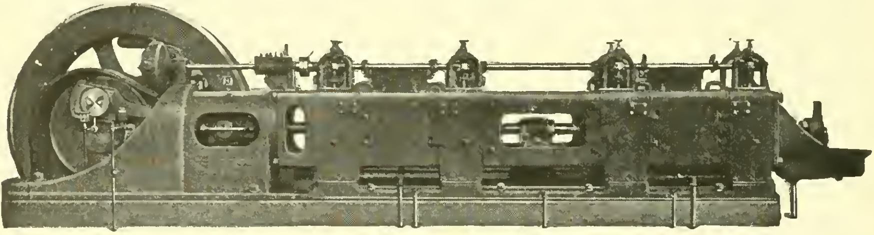

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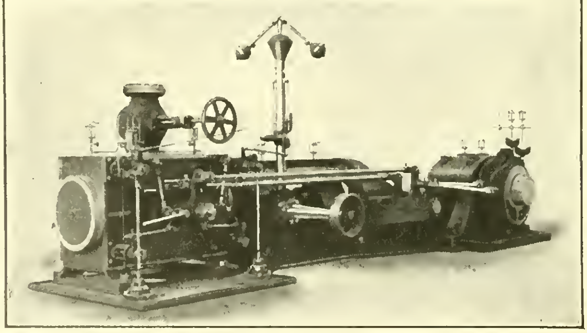

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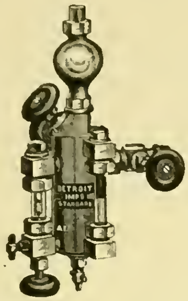

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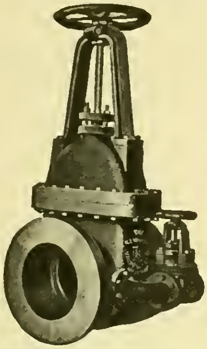

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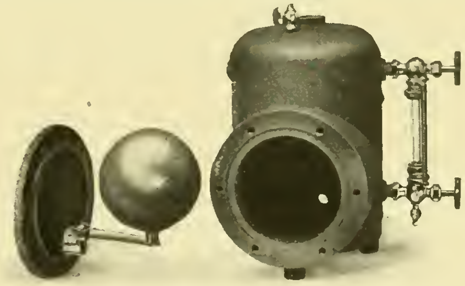

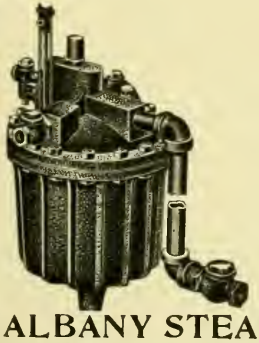

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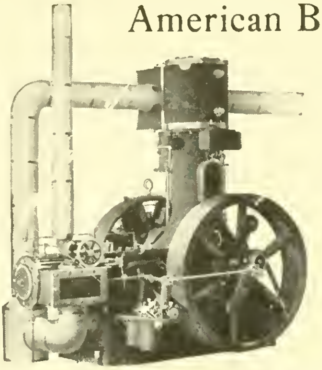

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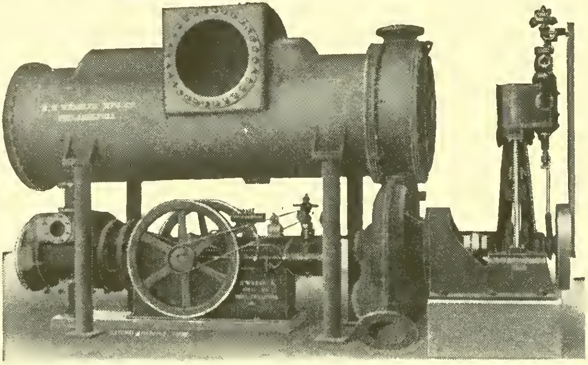

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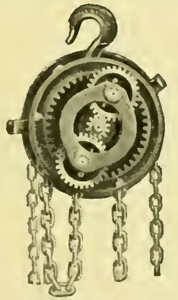

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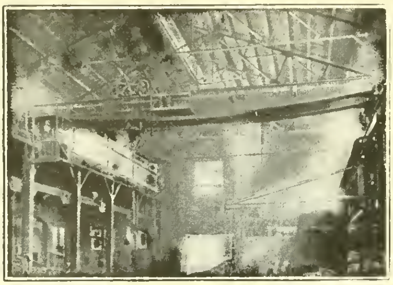

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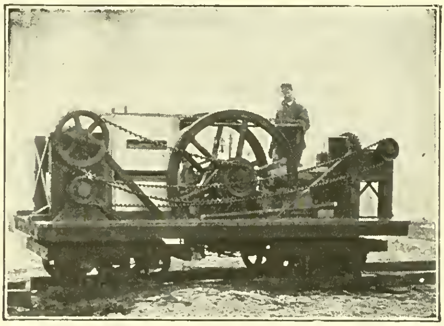

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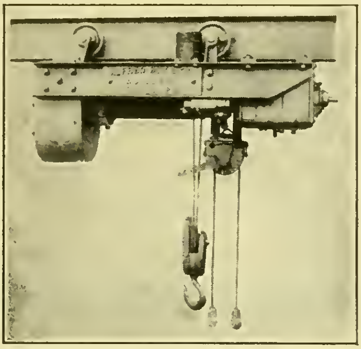

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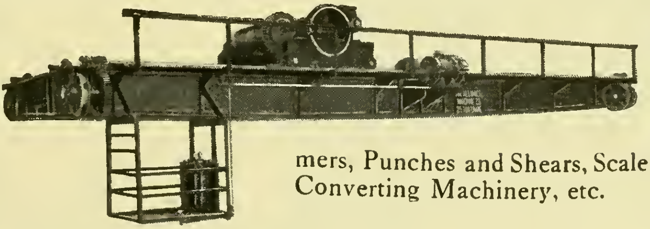

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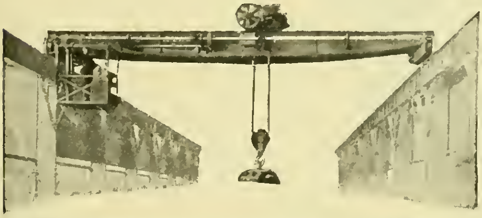

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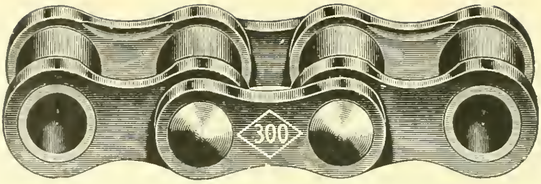

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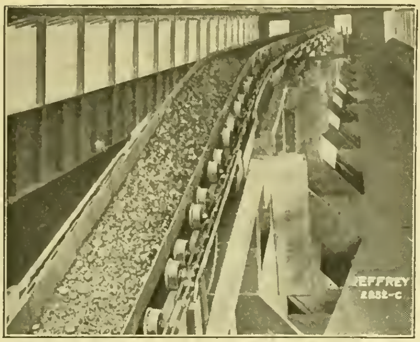

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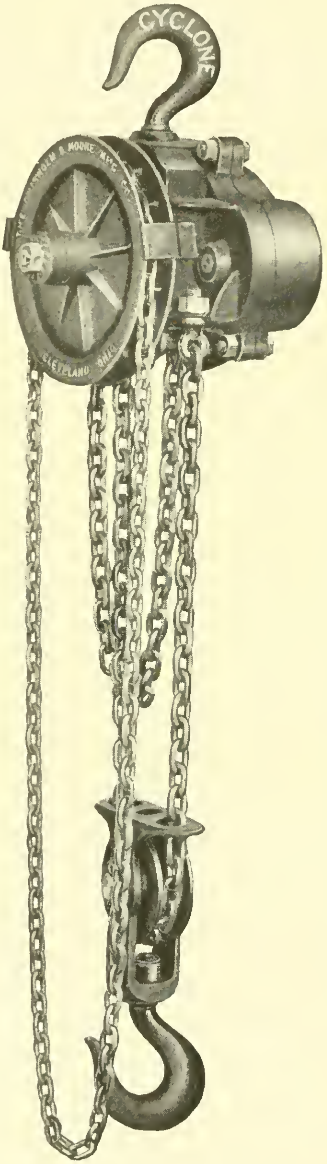

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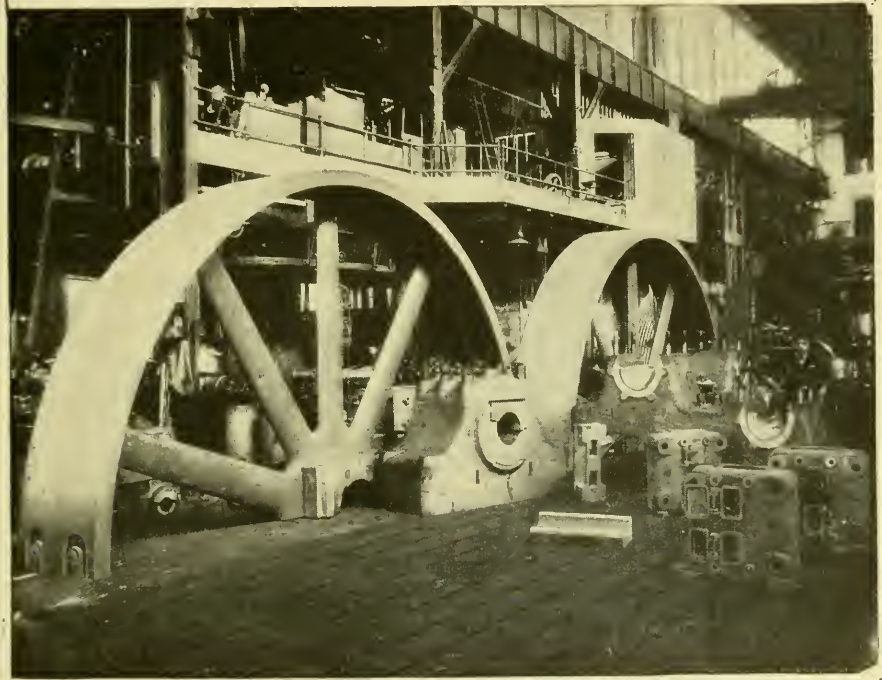

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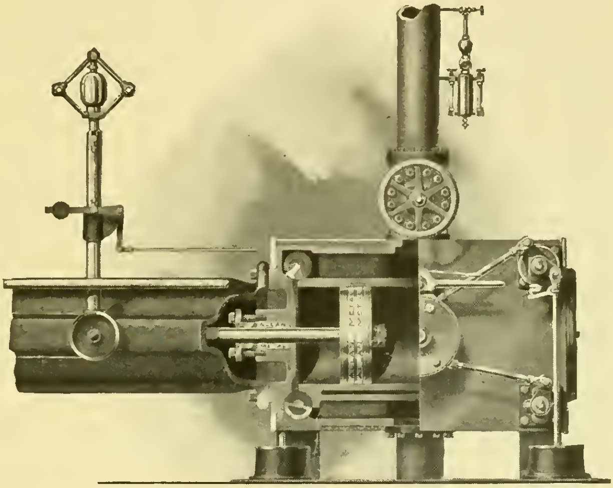

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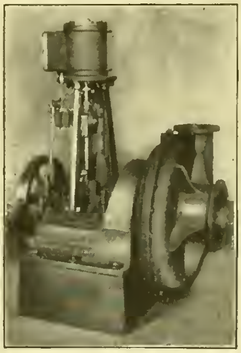

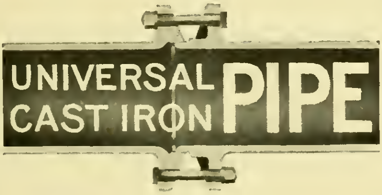

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ALPHABETICAL LIST OF ADVERTISERS

Page
Albany Steam Trap Co.........17, 39
Allan & Son, A.................27, 52
Alliance Machine Co............21, 47
Almy Water Tube Boiler Co 36
Alvey-Ferguson Co............... 47
American Engine Co............18, 36
American Goetze-Gasket & Packing Co.................14, 39
American Pulley Co............. 50
American Steam Gauge & Valve Mfg. Co....................... 40
American Steam Pump Co......... 44
American Tool & Machine Co 31
Arnold Co., The................... 30
Ashton Valve Co.................. 40
Atlantic Hydraulic Machinery Co... 44

Bacon, Earle C. 30
Baldwin, Bert. L................. 30
Ball Engine Co................... 36
Barr, H. G....................... 31
Beggs & Co., Jas...............11, 38
Belts Machine Co................ 31
Blaisdell Machinery Co........... 35
Blake Co., Geo. F................ 44
Booth Co., L. M.................. 40
Box & Co., Alfred.............21, 47
Bruce-Macbeth Engine Co......... 38
Buckeye Engine Co.............11, 36
Builders Iron Foundry..........20, 44
Bulkley, Henry W................ 40

Caldwell & Son Co., H. W.......... 47
Carborundum Co.................. 31
Card Mfg. Co., S. W............... 31
Carlyle-Johnson Machine Co....... 50
Carpenter Tap & Die Co., J. M ... 5, 31
Carrier Air Conditioning Co......27, 52
Central Foundry Co.............29, 52
Chapman Ball Gearing Co 52
Chapman Valve Mfg. Co........... 40
Chisholm & Moore Mfg. Co....24, 47
Cincinnati Gear Cutting Machine Co........................... 31
Cincinnati Shaper Co............. 31
Clarkson School of Technology... 30
Cleveland Crane & Engineering Co 21, 47
Cleveland Pneumatic Tool Co...... 35
Conard, William R................ 30
Crosby Steam Valve & Gage Co 40
Dallett Co., Thos. H............. 35

Page
Darley Engineering Co.......... 47
Davidson Co., M. T.............. 44
Dean, F. W....................... 30
Deane Steam Pump Co........... 44
Dearborn Drug & Chemical Wks.. 36
Detroit Lubricator Co.........17, 40
Diamond Chain & Mfg. Co......22, 50
Dixon Crucible Co., Joseph......14, 40
Dodge Co., J. M...............20, 48
Dodge Mfg. Co.................25, 50
Du Bois Iron Works............16, 38

Eastern Machinery Co............ 48
Electric Controller & Mfg. Co...19, 48
Engineering Schools & Colleges.... 30
Erie City Iron Works............. 36
Errington, F. A..................6, 32
Exeter Machine Works.......... 46

Fay Machine Tool Co............ 32
Fellows Gear Shaper Co. 32
Frick Co......................... 52

Gas Power Co.................... 38
General Electric Co 8, 51
Golden-Anderson Valve Specialty Co........................14, 41
Goyne Steam Pump Co........... 44
Grant Manufacturing & Machine Co.......................... 32

Hanna Engineering Works....... 43
Harrisburg Foundry & Machine Works....................... 36
Heine Safety Boiler Co.........16, 37
Herrick, J. A..................... 30
Hill Clutch Co................... 50
Holyoke Machine Co............. 45
Homestead Valve Mfg. Co........ 41
Hooven, Owens, Rentschler Co..16, 37
Hughson Steam Specialty Co...... 41
Hurley & Co., D................. 30
Hyatt Roller Bearing Co.......... 52

Ingersoll Milling Machine Co..... 32
International Machine Tool Co.... 32

Jacobson Engine Co.............. 38
Jeanesville Iron Works Co......29, 45
Jeffrey Mfg. Co.................23, 48
Jones & Lamson Machine Co....23, 32

Kellogg Co., M. W................ 52
Kennedy Valve Mfg. Co........17, 41
Knowles Steam Pump Works.... 45

Page
Laidlow-Dunn-Gordon Co......... 35
Le Blond Machine Tool Co., R. K.. 32
Leschen & Sons Rope Co., A...... 48
Lidgerwood Mfg. Co............ 48
Lindstrom, John T............17, 41
Link-Belt Co.................23, 48
Link Chain Belt Co............20, 48

McCord & Co.................... 41
McGowan & Co., John H.......... 45
Main, Chas. T.................. 30
Manning, Maxwell & Moore.....7, 33
Mason Regulator Co............. 41
Mietz Iron Foundry & Machine Works, August................. 38
Moran Flexible Steam Joint Co.... 41
Morehead Mfg. Co............... 42
Morgan Engineering Co.......... 49
Morris Machine Works.........29, 45
Morse Twist Drill & Machine Co. 7, 33
Murray Iron Works Co.........12, 37

National Brake & Clutch Co...... 50
National Machine Co............ 33
National Machinery Co........ 7, 33
National Meter Co............10, 38
Nelson Valve Co..............15, 42
Newark Gear Cutting Machine Co.........................6, 33
New York University School of Applied Science............... 30
Niagara Machine & Tool Works.... 33
Nicholson & Co., W. H.......... 42
Niles-Bement-Pond Co........1, 33
Northern Engineering Works....21, 49
Nye Steam Pump Works........ 45

Ohio Elevator & Machine Co...... 49
Ohio Injector Co................ 42
Oneida Steel Pulley Co.......... 51
O'Neill, J. G................... 30

Pennsylvania Flexible Metallic Tubing Co.......................42
Polytechnic Institute of Brooklyn. 30
Poole Engineering & Machine Co.. 51
Powell Co., The Wm............ 42
Power & Mining Machinery Co.... 39
Power Plant Specialty Co........ 42
Professional Cards.............. 30
Providence Engineering Works.. 37

Quimby, Wm. E................. 45
Quint, A. D.................... 33

Page
Reliance Electric & Engineering Co........................ 51
Rensselaer Polytechnic Institute.. 30
Ridgway Dynamo & Engine Co..13, 37
Risdon-Alcott Turbine Co......... 45
Riverside Engine Co...........16, 39
Robb-Mumford Boiler Co......12, 37
Robins New Conveyor Co........ 49
Rockwood Manufacturing Co.... 51
Roebling's Sons Co., John A....22, 49
Root & Van Dervoort Engineering Co....................... 39
Ruggles-Coles Engineering Co.... 46
Russell, Burdsall & Ward Bolt and Nut Co................ 6, 34

Seneca Falls Mfg. Co...........5, 34
Shaw Electric Crane Co.......... 49
Siemens-Schuckertwerke.......... 51
Simmons Co., John............9, 42
Skinner Chuck Co............... 34
Smith Co., S. Morgan............ 46
Snow Steam Pump Works...... 46
Springfield Machine Tool Co...... 34
Standard Tool Co..............7, 34
Stewart Heater Co.............. 43
Stroudsburg Engine Works...... 49
Struthers-Wells Co............10, 39
Sturtevant Co., B. F............ 46
Superior Gas Engine Co.......... 39

Tufts College................... 30

University of Michigan.......... 30

Wagner Electric Mfg. Co.......... 51
Walch & Wyeth..............13, 43
Waltham Machine Works........ 34
Warner & Swasey Co..........1, 34
Washburn Shops..............6, 34
Webster Mfg. Co................ 49
Wetherill & Co., Robt............ 37
Wheeler Condenser & Engineering Co....................... 43
Wheeler Mfg. Co., C. H........... 43
Wheelock, Lovejoy & Co......... 35
Whiting Foundry Equipment Co., 20, 43
Whiton Machine Co., D. E......4, 35
Wiley & Russell Mfg. Co.......... 35
Willoughby, A. B................ 43
Wing Mfg. Co., L. J.............. 46
Wisconsin Engine Co..........9, 37
Worthington, Henry R.......... 46

Yale & Towne Mfg. Co........19, 49

21

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THE
JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

OCTOBER 1909

MEETINGS OF THE SOCIETY: NEW YORK, OCTOBER 12; ST. LOUIS, OCTOBER 16; BOSTON, OCTOBER 20; ANNUAL MEETING, NEW YORK, DECEMBER 7-10

R 1909 VOL. 31 No. 8

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLISHED AT 2427 YORK ROAD - - - - BALTIMORE, MD.
EDITORIAL ROOMS, 29 WEST 39TH STREET - - - - NEW YORK

CONTENTS

Society Affairs.. 3

Hudson-Fulton Celebration (3), Meetings in October (3); Annual Meeting (4); Notice of Amendment to Constitution (5); Hudson-Fulton Exhibit (6); Fulton Monument (7); General Notes: Gift to the Library (9); Aviation Week at Rheims (9); Pan-American Scientific Congress (10). Other Societies: International Congress for Testing Materials (12); American Scientific Congress (12); American Institute of Mining Engineers (13); Illuminating Engineering Society (13); Association of Edison Illuminating Companies (14); New England Water Works Association (15); Nova Scotia Society of Engineers (15); Association for the Advancement of Science (15); The Institution of Mechanical Engineers (16); Fulton as an Engineer (17); Early Steam Navigation (23); Personals (35); Necrology (37).

Papers

Tan Bark as a Boiler Fuel, D. M. Myers............................ 951
The Best Form of Longitudinal Joint for Boilers, F. W. Dean........... 973
An Experience with Leaky Vertical Fire-Tube Boilers, F. W. Dean.... 977

Discussion at the Washington Meeting

Tests on Compressed-Air Pumping Systems of Oil Wells, E. M. Ivens. F. A. Halsey, S. A. Moss, J. G. Callan, The Author................. 987
Some Properties of Steam, R. C. H. Heck. S. A. Moss, G. A. Goodenough, The Author... 991
A New Departure in Flexible Staybolts, H. V. Wille. Wm. Elmer, W. E. Hall, Alfred Lovell, F. J. Cole, The Author...................... 995
Automatic Feeders for Handling Material in Bulk, C. Kemble Baldwin. T. A. Bennett, The Author.................................1003
Specific Volume of Saturated Steam, C. H. Peabody. W. D. Ennis, The Author. 1005
A New Transmission Dynamometer, Wm. H. Kenerson. A. F. Masury..1007
A Unique Belt Conveyor, E. C. Soper. T. A. Bennett, Harrington Emerson, F. J. Miller, The Author..............................1008

CONTENTS—Continued

New Books 1011
Employment Bulletin 1013
Changes in Membership 1015
Coming Meetings 1019
Accessions to the Library 1022
Officers and Committees 1025

The Journal is published by The American Society of Mechanical Engineers twelve times a year, monthly except in July and August, semi-monthly in October and November.

Price, one dollar per copy—fifty cents per copy to members. Yearly subscription, $7.50; to members, $5.

Application filed for entry at the Postoffice, Baltimore, Md., as second-class mail matter under the act of March 3, 1879.

The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C 55

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 31 OCTOBER 1909 NUMBER 8

THE Hudson-Fulton celebration, now in progress in New York City, emphasizes as have few events the debt of the present age to the engineer. The American Society of Mechanical Engineers has entered into the spirit of the celebration by preparing an exhibit in the rooms of the Society as a modest representation of the engineering profession. The exhibit, which has been announced through the daily and technical press and the literature issued by the Hudson-Fulton Celebration Committee, illustrates the development in marine engineering, beginning with the days of Fitch, Fulton and Stevens. An account of the exhibit is published elsewhere in this number. It is fortunate that the Society could thus contribute to the features of the celebration and so emphasize the progress in engineering which is now being commemorated.

MEETINGS FOR OCTOBER

Meetings of the Society are to be held during the month of October as follows:

In New York, on Tuesday evening, October 12, at eight o'clock, in the Engineering Societies Building, with a paper by Prof. R. C. Carpenter of Cornell University upon The High-Pressure Fire System of New York City.

In St. Louis, jointly with the Engineers Club of St. Louis, on Saturday evening, October 16, when Professor Carpenter will again present his paper upon The High-Pressure Fire System.

In Boston, on Wednesday evening, October 20, at eight o'clock, jointly with the Boston Society of Civil Engineers in Chipman Hall a paper will be presented by Prof. Gaetano Lanza and Lawrence S. Smith on Comparison of Results Obtained by the Use of Three Theories of the Distribution of the Stresses in Reinforced Concrete Beams, with the experimental results.

In conducting meetings in St. Louis and Boston the Society is entering into broader activities than ever before and affording the membership a greater opportunity to attend meetings, participate in the discussion of papers and meet members and engineers in attendance at the meetings. The meetings in St. Louis and Boston as well as in New York are to be regular meetings of the Society, with the same standards maintained in regard to papers, discussion and general conduct of the meetings that have been established by the conventions and other regular meetings of the Society held in previous years.

Of the two papers to be given in October, that by Professor Carpenter introduces a subject which should draw out a great deal of discussion. The first high-pressure fire system in the country was installed at Detroit in 1888, where it was designed to fill the mains by means of steam-driven pumps on boats. There are now systems installed or in process of construction in Philadelphia, Brooklyn, Baltimore, Boston, Buffalo, San Francisco, Toronto and possibly other places. In some of the installations multi-stage centrifugal pumps are employed and in others plunger pumps are used. There is therefore an opportunity for discussion of high-pressure systems, as such, and also of the relative advantages and characteristics of different types of pumps for high-pressure work.

The paper by Professor Lanza and Mr. Smith gives the results of extended experiments upon full-sized reinforced concrete beams with well-developed theories, the paper forming an important contribution to the all-important subject of reinforced concrete construction.

ANNUAL MEETING

Preparations are actively under way for the annual meeting to be held in New York, December 7–10, detailed announcement of which will be made later. Valuable papers have already been received. As advance publication must be given to papers presented at the meeting and ample time allowed for their preparation and distribution in order to secure discussion, papers submitted for the annual meeting should be in this office by October 15 and in no case later than November 1.

NOTICE OF AMENDMENT TO CONSTITUTION

Under the requirements of C57 notice is given of the following proposed amendments to the Constitution:

C45 *Public Relations Committee.* Amend C45 of the Constitution by adding after the words "Research Committee" the words, "Public Relations Committee."

Presented and approved under requirements of C57 (Washington, D. C.) May 5, 1909.

C10 *and* C11. Presented and approved under requirements of C57 at the business session of the Society at the Washington Meeting, May 5, 1909, as follows:

> C10 An Associate shall be thirty years of age or over. He must have been so connected with some branch of engineering or science, or the arts, or industries, that the Council will consider him qualified to coöperate with engineers in the advancement of professional knowledge. He need not be an engineer.

Approved and confirmed by Council at its meeting June 2, 1909, with the following recommendation: Omit the words "He need not be an engineer."

C10 as finally amended to read:

> C10 An Associate shall be thirty years of age or over. He must have been so connected with some branch of engineering or science, or the arts, or industries, that the Council will consider him qualified to coöperate with engineers in the advancement of professional knowledge.
>
> C11 A Junior shall be twenty-one years of age or over. He must have had such engineering experience as will enable him to fill a responsible subordinate position in engineering work, or he must be a graduate of an engineering school. A person who is over thirty years of age cannot enter the Society as a Junior.

The Council recommend: To substitute for the last sentence of the amendment the following: "A person who is over thirty years of age shall not be eligible to membership in the Society as a Junior."

C11 as finally amended to read:

> C11 A Junior shall be twenty-one years of age or over. He must have had such engineering experience as will enable him to fill a responsible subordinate position in engineering work, or he must be a graduate of an engineering school. A person who is over thirty years of age shall not be eligible to membership in the Society as a Junior.

[*Extract from C57.* At that annual meeting such proposed amendment shall be presented for discussion and final amendment, and shall subsequently be submitted to all members entitled to vote, provided that 20 votes are cast in favor of such submission. The final vote on adoption shall be by sealed letter-ballot, closing at twelve o'clock noon, on the first Monday of March following."]

THE SOCIETY'S HUDSON-FULTON EXHIBIT

In keeping with the celebration of the discovery of the Hudson River and the successful application of steam to navigation, the House Committee of the Society has appointed a subcommittee, with Edward Van Winkle as chairman, and has prepared an exhibit of models, drawings, letters, books and other items of interest related to early steam navigation.

This exhibit is the only participation of any engineering organization as such in the celebration, and much credit is due Mr. Van Winkle for the time and attention devoted to its preparation. The aim has been to make it of interest to the general public as well as the engineer. The exhibit room is open from 9 a.m. to 5 p.m. every week day. A list of the exhibits follows:

The model of the Clermont, loaned by the Smithsonian Institution, shows that vessel as she was at the time of her maiden trip. After making several trips during the fall of 1807, the Clermont was docked at Browne's shipyard and fitted up for regular passenger traffic.

The model of the Phoenix, loaned by the Smithsonian Institution, shows Stevens' boat at the time of making her notable New York-Philadelphia trip—the first ocean voyage made by a steam vessel.

A model of a steamboat built by John Fitch in 1786, also loaned by the Smithsonian Institution, has a peculiar arrangement of oars dipping into the water something like a canoe paddle. Despite its clumsy appearance the boat made a trip of 20 miles on the Delaware River.

A 9-ft. model of the Deutschland, loaned by the Hamburg-American line, shows by contrast the remarkable development in steam navigation during the last one hundred years.

Fulton painted an oil portrait of himself while a pupil of Benjamin West. This portrait was presented to the Society by Mrs. R. Anna Cary.

The Fulton dining table, owned by the Society, is of mahogany, 8½ ft. long and 5 ft. wide. It was presented to Mrs. Egleston House by Robert Fulton and passed from her hands to Geo. W. Egleston, and from him to his brother Thomas Egleston, who presented it to the Society in 1891.

Two autograph drawings by Fulton are exhibited, one of them, a brush drawing of a high-level canal, presented by Cornelia J. Carll, shows his artistic ability as well as his mechanical genius. The other drawing is of the Sound steamer Fulton, built in 1813, and was presented by Louisa Lee Schuyler.

The drawing of the Fulton is reproduced on a bronze tablet made in connection with the Fulton monument erected by the Society over Fulton's grave in Trinity churchyard. The tablet also gives a short description of the Clermont.

Henry Harrison Suplee, member of the Committee on Society History, has presented a photograph of a letter by Fulton describing his experimental boat on the Seine, with copies of other letters by Fulton and his friends.

A Hudson River Guide, published in 1850, loaned by H. J. Gelien, describes the various points of interest on the Hudson and gives the time of sailing of the Hudson River boats of that period.

An oil portrait of James Watt, presented by past members of the Council, a copy of a portrait by deBreda, now in the possession of John Scott of Hawkhill, Greenock.

An oil portrait of Capt. John Ericsson, painted by Ballin of Stockholm, shows the designer of the Monitor at the age of 59. A bust of Ericsson, by Kneeland, was presented to the Society by James Mapes Dodge, Past-President, Am.Soc.M.E.

A solid silver model of the Half Moon has been loaned by Tiffany & Co.

Model of the Monitor presented by Thomas F. Rowland who built the Monitor at the Continental Iron Works.

Models, exhibited by Ericsson at the Centennial Exposition, loaned by the United Engineering Society.

Early books on steam navigation, from the Library of the Society.

Copy of a letter from Fulton to Boulton & Watt in 1810, ordering an engine for another boat.

Copy of letters by Fulton's workmen.

Drawings showing the comparative size of the White Star S.S. Olympic, Clermont and Half Moon; of New York's early water works, corner of Centre and Reade Streets; a water works note issue in 1774; all loaned by Daniel Arthur.

Color print of the Half Moon.

Fac-simile of Rules and Regulations for passengers in the Clermont.

Sketch of James Watt discovering the condensation of steam.

Photographs of a letter written by Fulton to Boulton & Watt, describing the Clermont and ordering an engine for another steamboat. Presented by the Smithsonian Institution.

A print of the original oil painting by W. F. Halsall of the battle between the Monitor and the Merrimac in the collection of the late Thomas Fitch Rowland, the builder of the Monitor.

Bills, receipts, etc., written by John Fitch; stock certificate issued by John Rumsy; copy of New York Herald of 1815 containing items of steamboats; copy of Washington Gazette of 1821 attacking Fulton; all loaned by Dr. C. S. Bullock, of Stratford, Conn.

DECORATION OF THE FULTON MONUMENT

On the morning of September 24, in the presence of officers and members of The American Society of Mechanical Engineers and of the Pennsylvania Society, wreaths were placed on the Fulton monument erected in 1901 by this Society in Trinity churchyard, New York. The Society was represented by Jesse M. Smith, President, and Calvin W. Rice, Secretary. The Pennsylvania Society was represented by Robert Mazet, Vice-President, and Barr Ferree, Secretary. J. M. Schroeder, commissioner from Pennsylvania, was also present.

Members of both societies assembled in the lobby of the church and, preceded by Dr. Manning, rector of Trinity Church, marched to the Fulton Monument. Dr. Manning offered prayer in part, as follows:

Almighty God, Who givest breath to every living thing, and of whose power it is that peoples, nations and kindreds of men stretch forth the curtains of their habitations, we give Thee thanks for the patience and genius with which Thou has endowed men that they might bring into subjection the mighty forces of the universe, and fulfill Thy command to subdue and replenish the earth. We thank Thee this day especially for these services, to us and to all people, of that one whose faithfulness and whose gifts of knowledge opened the way for our ships to traverse the great waters, and whose prayer it was that "the liberty of the seas might be the happiness of the earth."

Bless this land of promise with honorable industry, sound learning and pure manners; fashion into one happy people the multitude brought hither out of many kindreds and tongues; indue with the spirit of wisdom those whom we intrust in Thy name with the authority of governance, that all things may be so ordered and settled by their endeavors upon the best and surest foundations, that peace and happiness, truth and justice, religion and piety, may be established among us for all generations. And hasten the time, we pray Thee, when all peoples of the earth shall dwell together in righteousness and peace, and war shall be no more.

All of which we ask in the name of Jesus Christ, our most blessed Lord and Saviour. Amen.

The wreaths were then placed on the monument and the Lord's Prayer was recited, followed by the benediction. "Taps" sounded by a Seventh Regiment bugler brought the exercises to a close.

GENERAL NOTES

GIFT TO THE LIBRARY

The Western Electric Company has presented its valuable patent specification library to the library of the American Institute of Electrical Engineers. This gift, which constitutes the largest accession since the original creation of the library, will be added to the rich collection of technical literature housed in the Engineering Societies' Building.

The library consists of 461 leather-bound volumes containing approximately 100,000 specifications collected at a cost of over $4000. These specifications begin with May 30, 1871, and run to December, 1908, thus covering the entire period of activity which includes the telephone, the electric light, electric railways and the electric motor. From May 30, 1871, up to the last day of 1887 the volumes are complete, and certified as containing all the specifications issued by the U. S. Patent Department. From July, 1887 to December 1, 1908, the volumes contain all the electrical specifications, which are not certified.

Mr. Edward Caldwell, chairman of the library committee of the Institute, has already taken in hand the proper installation of the books, that engineers may derive the greatest possible benefit from them, and has also taken measures to complete the set to date. This splendid contribution will doubtless prove one of the most valuable accessions possible, from the standpoint of practical utility, and will be likely to stimulate further generosity. It is a most fortunate coincidence that the Institute had already been presented with a set of specifications antedating the period included in this gift.

AVIATION WEEK AT RHEIMS

August 22 to 29 an aëronautic meet was held on the Béthény Plain, at Rheims, France, which has indicated unexpected progress in the science. In spite of some unfavorable weather conditions there was no fatal accident. There were 38 entries to the various contests, in which biplanes and monoplanes were about equally represented, the principal types being the Wright, the Voisin cellular, the Farman and the Curtiss biplane; and the Antoinette, the Blèriot and the Pelterie monoplane. In the competitions the biplanes showed themselves slightly superior, especially in regard to endurance, and the bicycle type of air-cooled motor outdid the motor-car water-cooled type of engine. In géneral, the heavier-than-air machine far surpassed the dirigible.

The principal contests were for the longest uninterrupted flight, the swiftest flight over outlined courses, passenger-carrying contests, and an altitude-contest. Prizes were offered to the value of $40,000.

The speed-contest for the Bennett International Aviation Trophy was won by G. H. Curtiss, representing the Aëro Club of America. Mr. Curtiss ran his 60-hp. biplane the 12.5 miles (twice around the course, in 15 min. $50\frac{3}{5}$ sec. Mr. Curtiss also won the longer speed-race of 18.6 miles, in 23 min. 29 sec.; and in a dash once around made 6.2 miles in 7 min. $48\frac{2}{5}$ sec., M. Bleriot winning this event in 7 min. $47\frac{4}{5}$ sec.

The distance contest for the Grand Prix de la Champagne et de la Ville de Rheims was won on August 27 by M. H. Farman in a biplane of his own type fitted with 50-h.p. Gnome revolving-cylinder motor and Bosch magneto-ignition. The condition of the flight was only 31 miles; Mr. Farman covered over 118 miles, in 3 hr. 15 min.

Mr. Farman also won the passenger-carrying contest, carrying at one time two passengers and making best speed record with one.

The winning machine in the height-competition, driven by Latham, reached a height of 508.5 ft. 35,400 ft. has, however, been reached by a manned balloon, carrying the German aëronauts Berson and Suering, who were unconscious at their highest point of flight.

FIRST TRIENNIAL PAN-AMERICAN SCIENTIFIC CONGRESS.

The report to Congress of the delegates of the United States to the First Triennial Pan-American (Fourth Latin-American) Scientific Congress, held at Santiago, Chile, December 25, 1908, to January 5, 1909, makes formal acknowledgment of special obligation to Calvin W. Rice, Secretary Am.Soc.M.E., for assistance to the delegation of the United States in securing papers for the engineering section.

Regret is expressed by the delegates that no engineer from the United States was present as a delegate, at the sessions of the section. Special mention is made of valuable papers by William H. Burr, Mem.Am.Soc.M.E., Mem.Am.Soc.C.E. on Reinforced Concrete Construction; W. J. Wilgus, Mem.Am.Soc.C.E., on Inter-Continental

Railways, and Frank J. Sprague, Mem.Am.Soc.C.E., Member and Past-President A.I.E.E., on The Application of Electricity to Railways. Other papers contributed through the Society were listed in The Journal for November 1908, page 19.

Recommendations and resolutions were adopted by the section as follows:

The speedy completion of the Pan-American Railroad.

That the economical use of water be given special attention in the countries of America; for the purpose of executing systematic irrigation works and also to stimulate united action on the part of those dependent on irrigation for the use of their lands, that every effort be made to stimulate the spirit of solidarity in order that such irrigation works may be carried out.

That it is highly important that public water-supply systems be established in the largest possible number of communities.

That at the next scientific congress the committee on organization submit a larger number of topics relating to irrigation; that the delegates submit the laws and regulations, and present papers relating to the use of water in their countries, the irrigation systems in use, and those in course of construction, and under consideration.

Topics for a special international conference were further suggested as follows: Type of building in countries subject to earthquakes; type of construction best adapted for piers and quays when the rivers are of great depth and swift current; preservation of native engineering terms.

The next Congress will be held in Washington, D. C., in 1912. A provisional committee to take the necessary steps for the formation of a permanent organization committee in the United States was appointed as follows: Dr. L. S. Rowe, Chairman, the director of the Bureau of the American Republics, the Commissioner of Education of the United States, William H. Holmes of the Smithsonian Institution, George M. Rommel of the Department of Agriculture. Dr. Enrique Ribeyro de Lisboa, of Brazil, was elected president of the Congress, to serve three years.

OTHER SOCIETIES

INTERNATIONAL CONGRESS ON TESTING MATERIALS.

The International Congress on Testing Materials was in session at the University buildings, Copenhagen, Denmark, during the week of September 10. The meeting was opened by Alexander Foss, president of the association. An important paper was presented by Paul Larsen, on The Development of the Danish Cement Industry. Papers were read in French, German and English. The next meeting will be held in New York, in 1912. Chas. B. Dudley, Mem.Am. Soc.M.E., was elected president of the International Association. Dr. Dudley was the representative of the United States at the Congress.

AMERICAN MINING CONGRESS

The twelfth annual session of the American Mining Congress is now being held at Goldfield, Nev., September 27–October 2. Prof. Joseph A. Holmes, of Washington, D. C., has been appointed Honorary Vice-President, to represent the Society at the Congress.

During the year several committees have been at work conducting investigations, reports of which will be made by the Chairmen as follows: Committee on Vertical Side-Line Law, Geo. W. Riter; Coal Tax Insurance Fund, Samuel A. Taylor; General Revision of Mining Laws, Walter R. Ingalls; Standardization of Electrical Equipment, Dr. Edward B. Rosa; Prevention of Mine Accidents, H. Foster Bain; National Forest Service, Col. A. G. Brownlee; Alaskan Mining Laws, J. L. Steele. The question of bringing about a greater use of silver, and decreasing the rate of exchange with countries using a silver standard, will be discussed, and Moreton Frewen, of London, James J. Hill and John Hays Hammond, have been invited to speak on this subject.

The State of Nevada has appropriated $5000 to pay the expense of collecting and classifying a comprehensive display of the state's mineral at Goldfield.

AMERICAN INSTITUTE OF MINING ENGINEERS

The ninety-seventh meeting of the American Institute of Mining Engineers for the reading and discussion of papers was held at Spokane, Wash., beginning September 27, 1909. There was much of professional interest in the excursions connected with the meeting, which included visits to the great copper plants at Butte and Anaconda, the mining and metallurgical operations in the Coeur d'Alene district and in the vicinity of Salt Lake, the mining exhibits at the Alaska-Yukon-Pacifiic Exposition in Seattle, the Tacoma smelter, the steel plant and lead smelter at Pueblo, Colo., and a special excursion into Yellowstone Park.

Among the papers presented at the meeting were Modern Progress in Mining and Metallurgy in the Western United States; (Presidential Address), by D. W. Brunton, Denver, Colo.; The Influence of Bismuth on Wire-Bar Copper, by H. N. Lawrie, Portland, Ore.; Dust Explosions in Coal-Mines, by F. Bache, Ft. Worth, Ark.; The Formation and Enrichment of Ore-Bearing Veins, by George J. Bancroft, Denver, Colo.; The Assay and Valuation of Gold Bullion, by Frederic P. Dewey, Washington, D. C.; Protective Value of Humidity in Dusty or Gaseous Coal-Mines, by James Ashworth, Congleton, England; An Adjustable Pyrometer Stand, by L. W. Bahney, Palo Alto, Cal.; The Ruble Hydraulic Elevator, by J. McD. Porter, Spokane, Wash.; Cyaniding Slime, by Mark R. Lamb, Milwaukee, Wis.; The Filing of Assay Samples for Use in Technical Laboratories, by Louis D. Huntoon, New Haven, Conn.; Barite Industry of the United States, by A. A. Steel, Fayetteville, Ark. There were also discussions on papers previously presented.

ILLUMINATING ENGINEERING SOCIETY

The sessions of the third annual convention of the Society of Illuminating Engineers were held September 27–29 in the auditorium of the Engineering Societies' Building, 29 West 39th St. A historical and educational exhibit was also held at 5 West 39th Street, with exhibits arranged by manufacturers of the commercial types of electric and gas lamps and accessories, showing the latest developments in the production and utilization of light. Plans were made to include the Hudson-Fulton celebration then in progress, omitting professional sessions on Tuesday, and holding an evening reception at the Machinery Club, at the top of the Hudson Terminal Building, from which an extended view of the spectacular illumination was afforded.

Important reports presented at the professional sessions were that of the committee on nomenclature and standards, Dr. Alex. C. Humphreys, Manager Am.Soc.M.E., *Chairman;* the sub-committee on units of flux, Dr. Clayton H. Sharp, *Chairman;* Papers: The Ethics of Illuminating Engineering, by E. L. Elliott; The Progress of Illuminating Engineering in Europe, by W. T. Owens; Notes on Chemical Luminescence of Rare Earths, by Dr. Angelo Simonini; The Light of the Fire-fly, by Dr. H. E. Ives and Dr. W. W. Coblentz; The Principles of Shades and Reflectors, by Dr. Louis Bell; Standard Relations of Light Distribution, by A. J. Sweet; Tests of Moore Tube Installation, New York Post Office, by Dr. E. P. Hyde and J. E. Woodwell, Mem.Am.Soc.M.E. On Tuesday evening a lecture was delivered by Dr. Charles P. Steinmetz, Mem.Am.Soc.M.E., on The Physiological Effects of Radiation.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES

The twenty-fifth annual meeting of the Association of Edison Illuminating Companies was held at Briarcliff Manor, N. Y., August 31 to September 2, 1909. Reports were received at this time from a number of committees, including that of the Committee on Meters, presented by Joseph W. Cowles, Chairman; the Committee on Incandescent Lamps, John W. Lieb, Jr., Mem.Am.Soc.M.E., Chairman; the Committee on National Code, Wm. C. L. Eglin, Chairman; the Committee on Steam Turbines, Alex Dow, Mem.Am. Soc. M.E., Chairman; and the Committee on Electric Heating and Kindred Uses of Electricity, John F. Gilchrist, Chairman. Papers were also presented on Prepayment Meters, by F. G. Vaughan; New Low-Pressure Turbine Installations, by W. L. R. Emmet, Mem.Am.Soc.M.E.; Gas Power, by I. E. Moultrop, Manager Am.Soc.M.E.; Standard Colors for Power Station Piping, by J. P. Sparrow, Mem.Am.Soc.M.E.; Special Illumination Features of the Hudson-Fulton Celebration, by Arthur Williams; A Neglected Phase of the Insurance Question, by Caryl D. Haskins, Mem.Am.Soc.M.E.; and Rotaries vs. Motor Generator Sets for Central Station Service, by C. W. Stone, Mem. Am. Soc.M.E.

The sessions closed with a dinner to Thos. A. Edison, Hon. Mem. Am.Soc.M.E.

NEW ENGLAND WATER WORKS ASSOCIATION

The annual convention of the New England Water Works Association was held in New York September 8 to 10. The time of the convention was well divided between presentation and discussion of papers, excursions and general sociability. Four or five papers and several committee reports were presented at the business sessions. The excursion feature of the convention was a trip September 10, to the Ashokan Dam, where the new Catskill water supply for New York City is being developed.

At the opening session, Wm. W. Brush, Engineer of Distribution of the Water Works of New York City, presented an address outlining the water supply system of greater New York.

NOVA SCOTIA SOCIETY OF ENGINEERS

The third annual meeting of the Nova Scotia Society of Engineers was held September 10, at New Glasgow. The papers presented for discussion were: Some Memoranda on Land Surveying in Nova Scotia, by R. R. McKenzie; Forest Conservation, by Professor Sexton; Forest Preservation, by C. M. O'Dell; The Relation of Forests to Stream Flow, by D. McD. Campbell; The Timber Assets of Nova Scotia, by A. R. McClean.

Officers were elected for 1909 as follows: President, S. Fenn; Vice-Presidents, J. A. Stairs, J. W. McKenzie; Secretary, J. Lorne Allan; Council, Prof. R. R. Keeley, Mem.Am.Soc.M.E., A. R. McClean, H. C. Burchell, D. McD. Campbell, J. G. McKenzie, A. G. Robb, Mem.Am.Soc.M.E., C. M. Archibald, W. G. Yorston.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The British Association for the Advancement of Science held its annual meeting at the University of Manitoba, Winnipeg, Man., during the week beginning August 25. Sir William H. White, Hon.Mem.Am.Soc.M.E., delivered the presidential address before the Engineering Section of the Association, which held five sessions.

Among the papers presented were: Hydroplanes or Skimmers, by Sir John Thornycroft; The City Hydro-Electric Plant, by C.B.Smith; Improvements in the Navigation of the St. Lawrence, by Lt-Col. W. P. Anderson; The St. Lawrence River, the Great Imperial Highway of Canadian Transportation, by Maj. G. W. Stephens; Engineering and Construction Features of the Panama Canal, by Col. G. W. Goethals;

The National Transcontinental Railway, by Duncan McPherson; Two Great Engineering Works on the Canadian Pacific Railway, by J. E. Schwitzer; Development and Future Possibilities of the Grain Industry of Western Canada, by G. Harcourt; Grain Handling, by W. B. Lannigan. Prof. J. B. Porter of McGill University made a preliminary informal report of the fuel tests being carried out by him for the Dominion Government.

The afternoons were chiefly occupied by excursions of engineering interest, among them to the yards and shops of the Canadian Pacific and Canadian Northern Railways, the high-pressure fire-service pumping plant, the municipal hydro-electric plant and St. Andrews lock on the Red River, etc. The evenings were devoted to popular lectures and social functions. The meetings were attended by six hundred delegates, including many from the United States.

THE INSTITUTION OF MECHANICAL ENGINEERS

The summer meeting of the Institution of Mechanical Engineers was held at Liverpool July 27 to 29, with an unusually large attendance. At the professional sessions the following papers were presented: Locomotives Designed and Built at Horwich, by G. Hughes; Reinforced Concrete, A. O. Auden; Advance of Marine Engineering, A. J. Macginnis; Electrical Operation of Textile Factories, H. W. Wilson; Indicating Gas Engines, Prof. F. W. Burshall.

Very enjoyable social features were provided and also engineering excursions, including trips to the Liverpool Electricity Works, shipyards and docks, the University laboratories, the Liverpool & Southport Electric Railway, Mersey Railway power house, and pumping station, the Horwich Locomotive Works, a Cunard liner, soap and match factories, a refrigerating plant, etc.

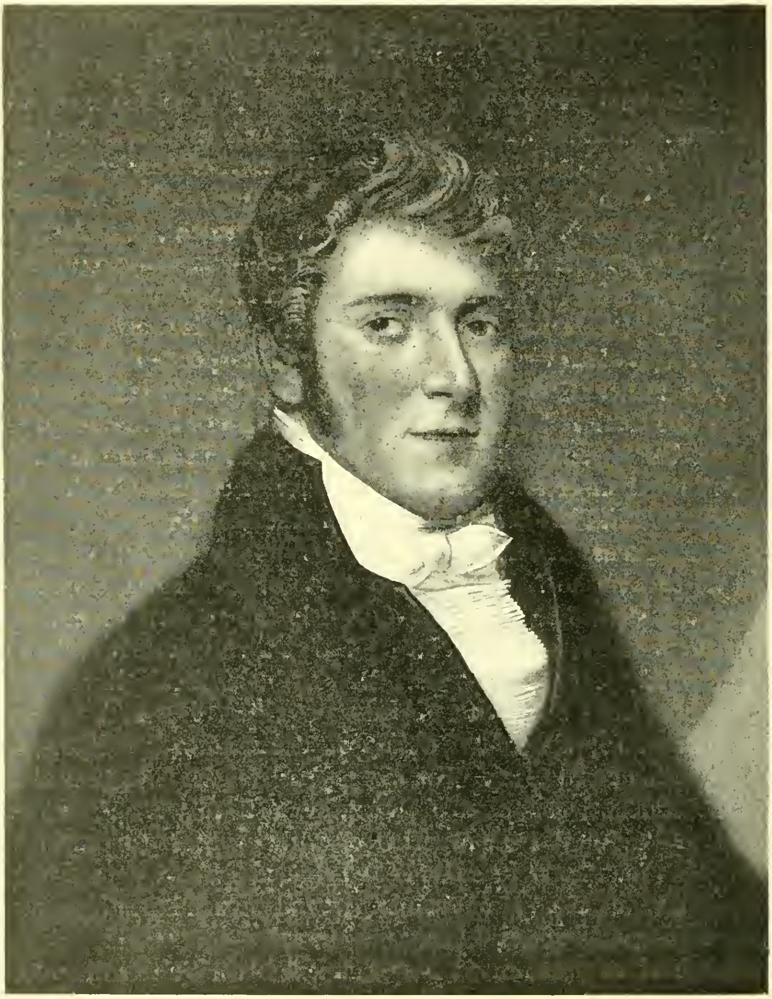
FULTON AS AN ENGINEER

Just now the popular conception of Fulton is as the man who *invented* steam navigation. To apply that title to him, however, is perhaps not to give sufficient credit to the work of previous investigators, from whose efforts Fulton obtained much of the knowledge applied in his own experiments. The achievement, therefore, for which he may be honored is the first successful *commercial* application of steam power to navigation on the Hudson River.

To think of him only in connection with the Clermont, however, is to lose sight of his versatility. Not only did he possess considerable talent as an artist, as evidenced by his oil paintings and drawings, but he also achieved distinction as a civil engineer in the design and construction of canal aqueducts and bridges, as an ordnance expert by his invention of torpedoes and as a naval engineer by his submarine work and the building of the first steam frigate.

His mechanical tastes, we are told, first appeared when as a boy of eight or nine he frequented the shops of mechanics, displaying such aptitude that he was allowed to help the apprentices and was always a welcome visitor. Hardly less marked was his ability to sketch readily the machines that drew his attention. The foundation of his future work with torpedoes was doubtless laid, when at fourteen he fairly haunted the shop of Messrssmith & Fenno, gunsmiths, in his home town. His biographer Reigart says that about this time the hard work of poling a boat home from a fishing trip suggested to Fulton the construction of paddle-wheels to propel the boat. The paddles were made detachable so that they could be hid in the bushes at the end of each trip; "and thus did they enjoy very many fishing excursions."

Though of so pronounced a mechanical bent, Fulton discovered such talent as an artist that at twenty-two he decided to become a pupil of Benjamin West in London. In 1797 he was invited to live with Joel Barlow in Paris and for seven years was as one of the family. During the time of his art studies, however, his mind had been occupied with mechanical things also. The first patent granted him, of which we have any knowledge, was in 1794 for a mill for sawing marble. Three years later he designed the first panorama exhibited



Robert Fulton

FROM A PAINTING BY HIMSELF, PRESENTED TO THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BY MRS. R. ANNA CARY, NOVEMBER 30, 1897 in Paris. It is said that at about this time Fulton sketched on the wall of his room the plan of a steamboat, which he called "the image of what will yet traverse the river and ocean."

In 1797 he also invented and patented a double inclined plane for canals, which was followed by a series of similar inventions for bringing canal boats from a higher to a lower level or the reverse, a machine for spinning flax, one for rope making, an excavating machine for canal work, an air gun, a cable cutter, torpedoes made of copper cylinders containing about 100 lb. of powder and set off by a gun-lock operated by clockwork, and a submarine boat, the Nautilus.

Damage by flood to an aqueduct over which passed the Shrewsbury Canal in England, led Fulton to design a cast-iron sectional aqueduct, which was built for crossing the Dee River at Pontcysyltee, about twenty-three miles southwest of Chester, in Scotland. Cast-iron bridges were also built after Fulton's design in Wandsworth, England, and at several other places on the Surrey Railway. In 1807, Fulton was invited by Secretary-of-War Dearborn to make the surveys for a canal from Lake Pontchartrain to the Mississippi, but declined because of his time being occupied with torpedo experiments and the building of the Clermont. In 1810, he was appointed by the New York Legislature as one of the commissioners to explore the route of a canal between the Hudson River and Lakes Ontario and Erie.

His experiments with torpedoes and submarines in France appear to have filled the British mind with alarm. He was invited by the British Ministry to London and in 1814 prepared to demonstrate the destructive power of his invention on the French flotilla lying at Boulogne. The torpedoes exploded without doing any damage, however, due, as believed by Fulton, to the fact that they were hung perpendicularly by the side of the vessel whereas they should have been so arranged that the current would sweep them under the vessel's bottom. He afterward made changes to obtain this result, and in October 1805, a vessel prepared for the test was blown up in Walmar Roads, near Deal. He repeated this performance in New York harbor, shortly before the Clermont's first trip, using a brig's hulk for his demonstration.

In March 1810 Congress appropriated $5000 for experiments with Fulton's torpedoes, the sloop-of-war Argus being prepared for the tests. A strong netting was suspended from her sprit-sailyard and anchored at the bottom; the vessel was surrounded by spars lashed together; she had grappling irons and heavy pieces of iron suspended from the rigging to drop on anything approaching; swords or scythes were fastened to long spars moving like sweeps, to mow off the heads of any who came near. Against this armor Fulton's torpedo was, of course, powerless, but it was admitted that any invention which would oblige a hostile vessel so to guard herself was of great importance in a system of defence. At this time Fulton tried out a harpoon and a cable cutter, both operated by the explosion of powder, and he later made experiments in the firing of cannon under water.

His initial plunge in a submarine was in the harbor of Brest in 1801. With three companions, Fulton went 25 ft. below the surface, remaining for an hour. The boat is described as being fitted with a mast and sail, which could be struck in about two minutes. Hand power was used for working some form of propeller. After the first trial, a cylinder of compressed air was used to freshen the vitiated air while the boat was submerged. A small glass window admitted enough light for movements to be directed. It appears that Fulton did not again take up work in this line until shortly before his death in 1815. A model of an improved boat was approved by Congress and work on the boat begun, but Fulton died before the hull was entirely finished.

Fulton's first experimental steamboat was tried on the Seine early in 1803. Robert R. Livingston, of New York, then United States Minister to France and himself a close student of the possibilities of steam navigation, had become interested in Fulton's ideas and had offered to provide funds for experiments. These proving successful, a contract was to be made for development in the United States. The night before the proposed trip of this boat, however, the hull proved too weak to sustain the heavy engine and boiler, and broke in two. The engine and boiler were raised and an almost entirely new boat built, measuring 66 ft. long and 8 ft. wide. The trial of this boat was satisfactory though her slow speed was somewhat disappointing to Fulton. Arrangements were then made to build a larger vessel in the United States, but owing to the lack of engine-building facilities in that country and in France, the engine was ordered from Boulton and Watt.

Fulton evidently went into the matter broadly and considered not only the propelling machinery but also the best form of hull for the desired results. In his patent specifications he writes: "The successful construction of steamboats depends on these parts (shape of bow and stern, draft, velocity, friction, total resistance, and power of the engine to give the necessary velocity) being well proportioned, whether wheels or other propellers be used, with the right proportion of the parts above mentioned, steamboats may be navigated by the propelling power of wheels, endless chains or paddles, but without the proportions which shall hereafter be explained, they cannot be successfully navigated, with either wheels, endless chains, paddles, or any other mode of taking the purchase on the water."

In his calculations Fulton used data obtained by Col. Mark Beaufoy from experiments made at Greenland Dock, near London. In his first specifications he gives the following figures for a boat to run one mile an hour to show his method of calculating the necessary power for different rates of speed:

	Pounds
The plus and minus pressure of 1 ft. 0.88 lb., which multiplied by 36 ft., the boat's bow, is	31.68
Friction on 848 feet of bow and stern, at 0.70 lb. for 50 sq. ft., is	11.90
Friction on 2,200 sq. ft. of the body of the boat is	30.80
Total resistance of the boat	74.38
A like power for the propellers	74.38
Total power	148.76

This power must be felt at propellers repelling water one mile an hour, or one foot and a half a second, which is one-fourth slower than the motion of the piston; consequently one-fourth may be deducted from 148.76, leaving 111.57 the power of the engine: a cylinder 4 inches diameter, equals 16 round inches, and 8 lb. to the inch, gives 128 lb., which is sufficient power. The periphery of the propeller wheels must run two miles an hour, or 3 feet a second, equal to 180 feet a minute. If 11½ feet diameter 34½ ft. round, 5¼ revolutions in a minute gives 181 ft.; the engine strikes 15 double strokes a minute, the wheels make 5¼ revolutions in a minute; this is a proportion of near 3 to 1; hence the first mover or pinion from the engine may be 2 ft. diameter, the wheel on the water wheel shaft 6 ft. diameter: the total resistance of the boat is 74.38 lb.; one square foot of propellers running 1 mile an hour is 3.25; resistance 23 feet will give 74.75: this is 11½ ft. in each propeller.

In his second specifications Fulton deals more specifically with the calculations for the Clermont. He writes as follows:

My first steamboat on the Hudson's River was 150 ft. long, 13 feet wide, drawing 2 ft. of water, bow and stern 60 deg.; she displaced 36.40 cubic ft., equal 100 tons of water; her bow presented 26 ft. to the water, plus and minus resistance of 1 ft.; running 4 miles an hour.

	Pounds
12.37 lb. multiplied by 26, the bow of the boat	321
Friction on 2,380 superficial feet of bottom and sides, at 7.50 lb. or 50 superficial feet	352
Total resistance of the boat, running 4 miles an hour	673

	Pounds
A like power for the propellers	673
Total power felt at the propellers	1,346
The boat running 4 miles an hour is 6 feet a second; this is 3 times faster than the piston; hence, multiplied by	3
Necessary power of the engine, the piston running 2 ft. a second	4,038

This will require a 22-in. cylinder allowing 9 lb. purchase to the round inch; this engine would not occupy in the boat more space than in the small one, and it would not weigh 2 tons more than the 17-in. cylinder; hence, say weight of engine 22 tons, weight of boat 40 tons, total 62 tons; this leaves 38 tons for passengers or merchandize, with ample space, before it could bring her down to 2 ft. in the water; but drawing not more than 18 in. before cargo or passengers were in, and her resistance being diminished one-third, the above power would drive her 4½ miles an hour. The two preceding examples exhibit in a clear point of view the advantage to be gained in building a large boat, to carry a large and powerful engine.

A list of the steam vessels built by Fulton after the Clermont is given elsewhere in these pages. The Vesuvius, built in 1814, is said to have played an important part in the battle of New Orleans as a transport for troops and supplies.

By some Fulton is accused of plagiarism. It is true that he used data obtained by Mark Beaufoy in experiments made in England on the form of hulls. It also may be true that Fulton inspected Symington's boat in England and made such notes and observations as enabled him to build his boat on the Seine. But Beaufoy never applied his data to the building of steam vessels and Symington's boat never reached the stage of commercial utility.

It is interesting to note Fulton's own view of his work in his patent of February 11, 1809, in which he claims to be "the first who had laid down rules that will secure success in building such boats or vessels; no patent or publications having hitherto appeared, in which exact and mathematical principles are explained to guide artizans to success in works of this kind."

He says further: "The development of these principles is indispensable to the most perfect construction of steamboats; it is owing to a want of accurate knowledge of these principles that the essays on steamboats, which have been made in different countries for thirty years, have hitherto failed."

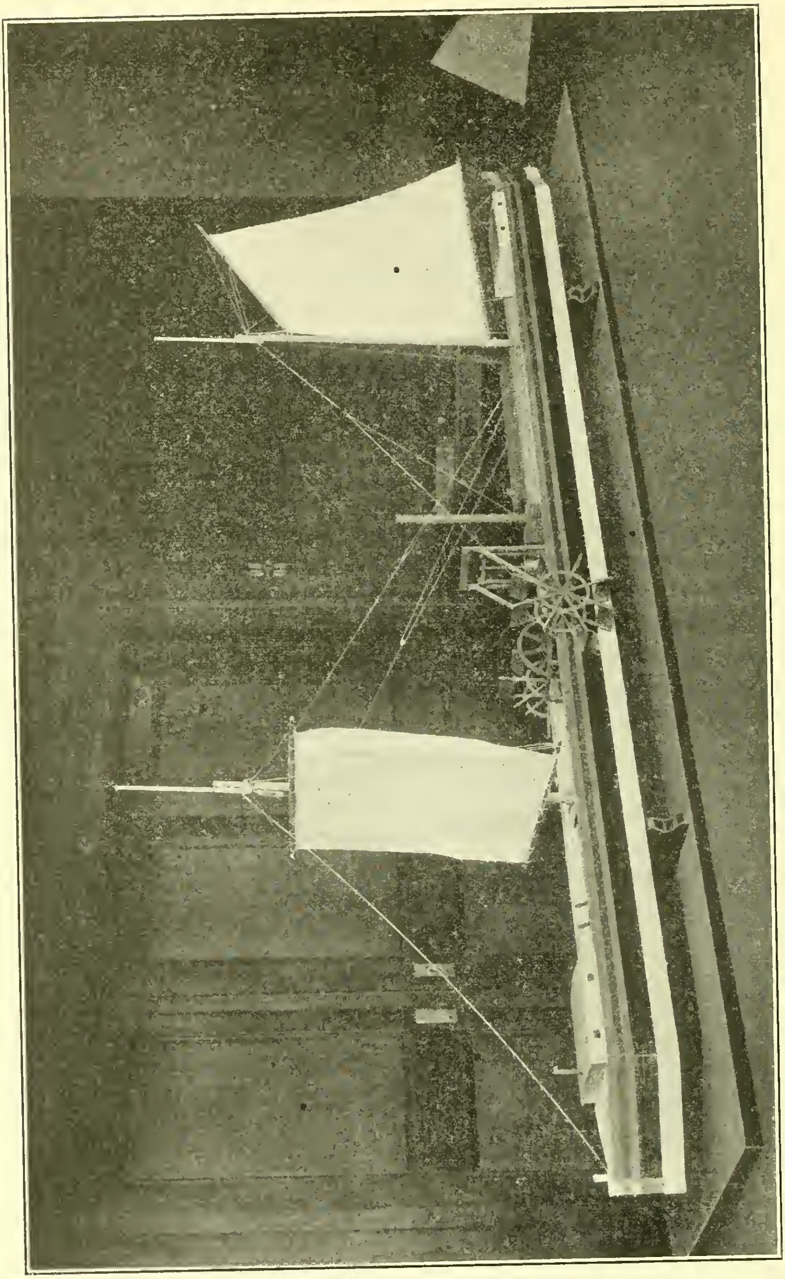
A BRIEF HISTORY OF EARLY STEAM NAVIGATION IN THE UNITED STATES

The celebration at this time of the first successful commercial application of steam power to navigation makes of interest the following brief review of the work of three men—Fulton, Stevens and Fitch—who played an important part in the development of the art.

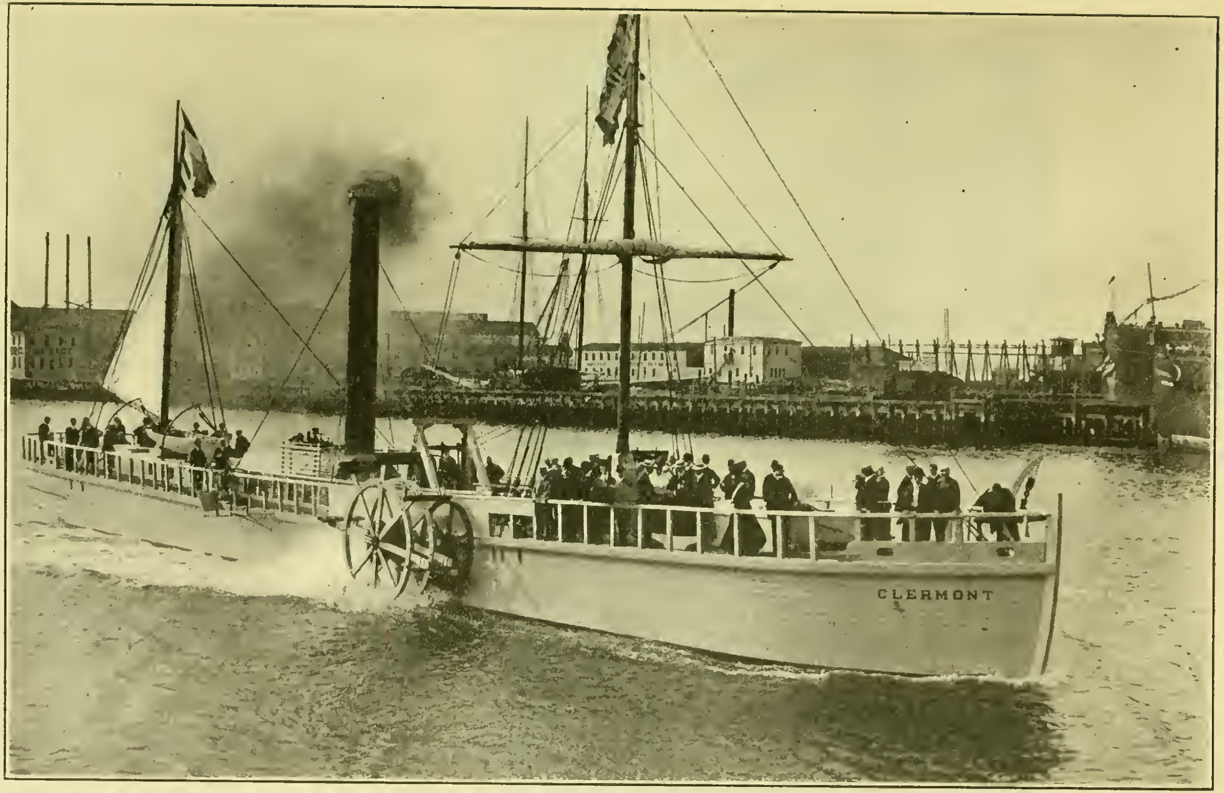
Fulton, who possessed considerable talent as an artist, appears to have first taken up the study of steam navigation while a pupil of Benjamin West in London. Later he went to Paris and while there interested Robert R. Livingston, of New York, in his ideas, to such an extent that Livingston agreed to supply the funds necessary for experiments. These proving successful a contract was to be made for development in the United States.

A vessel 66 ft. long and 8 ft. wide was built in France, and fitted with an engine the builders of which are not stated, though probably they were Boulton & Watt of England. After some mishaps, a successful trip was made on the Seine in 1803. Arrangements were then made to build a larger vessel in the United States, but owing to the lack of engine-building facilities in that country and in France, the engine was ordered from Boulton & Watt. In Fulton's diary the cost of the engine is given at 548£ and that of the copper boiler, weighing 4,399 lb., at 2s. 2d. the pound or £476 11s. 2d. The boiler was bought of Cave & Son.

Existing data of the engine are somewhat at variance, chiefly in regard to the relative arrangement of crankshaft, paddle-wheels and flywheel, though there is no doubt that the cylinder was 24 in. in diameter and the stroke 4 ft. Professor Renwick in his life of Fulton says, "On the same axle with the crank were toothed wheels, which gave motion to pinions, and to axles of the pinions was adjusted a heavy flywheel." The paddle-wheels were evidently on the crankshaft but this is not stated. The foregoing arrangement is the same as that shown in Woodcraft's work on Steam Navigation published in London in 1848. The accompanying sketch, taken from Fulton's specifications of patent in 1809, shows but one flywheel, driven by pinions from the crankshaft, on which the paddle-wheels were placed.

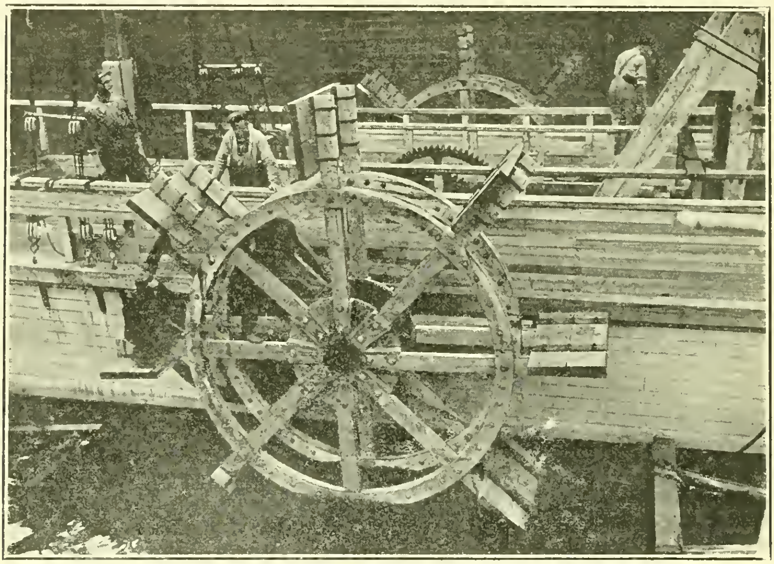


Model of the Clermont as she appeared on her Initial Trip



The Clermont II on her Official Trial Trip. She was Built at the Yards of the Staten Island Shipbuilding Co., from plans drawn by F. E. Kirby and J. W. Millard

The model of the Clermont from the Smithsonian Institution shows the flywheel and paddle-wheels on the same shaft driven by gears from the crankshaft. To complicate the matter further, data obtained by the designers of the Clermont II show one flywheel outside the hull on each side, and this is the arrangement on the vessel built for the Hudson-Fulton celebration.



A Paddle Wheel of the "Clermont" II

The dimensions of the hull are also a matter of dispute. The Smithsonian model was built from a description in a letter from Fulton to Boulton in which the length is given as 175 ft., the beam 12 ft., and the depth 8 ft. In his patent specification Fulton gives the dimensions as 150 ft. long and 13 ft. wide. In the enrollment made at the New York custom house, the vessel "having been enlarged" measured 150 ft. long and 18 ft. wide. These are doubtless the dimensions after the vessel was altered in the winter of 1807 to fit her for regular passenger traffic.

The hull of the Clermont was built at the shipyard of Charles Browne on the East River near Corlaer's Hook, opposite the Brooklyn Navy Yard. The sides of the hull were straight and the bottom flat, the angle included by both bow and stern being 60 deg. A square-rigged mast was placed forward and a schooner-rigged mast aft. During the first voyage a tiller was used for steering, but a wheel was afterward placed forward over the engine.

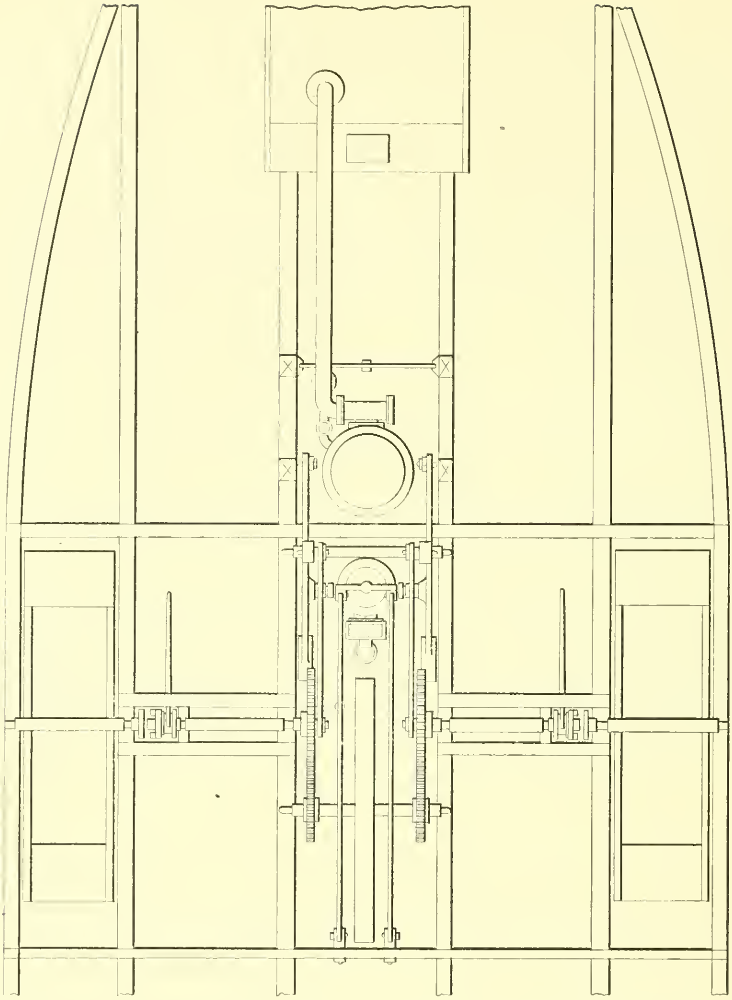
The first trip was made on Monday, August 21, 1807, from New York, the Clermont leaving at 1 p.m. and arriving at Clermont, Livingston's estate, at 10 a.m. Tuesday, having covered 110 miles. On Wednesday, leaving Clermont at 9 a.m., Albany was reached at 5 p.m.—a run of 40 miles in 8 hours. On Thursday at 9 a.m. the Clermont left Albany and arrived at Clermont at 6 p.m., leaving at 7 p.m. and arriving in New York on Friday at 4 p.m. In describing the trip in a letter to a newspaper, The American Citizen, Fulton wrote that the wind was ahead both ways so that no advantage was derived from the sails.

In discussing with Livingston the possibilities of financial return from the passenger traffic, Fulton wrote: "By carrying for the usual price there can be no doubt but the steamboat will have the preference because of the certainty and agreeable movement. I have seen the captain of a fine sloop on the Hudson. He says the average of his passages have been 48 hr. For the steamboat it would have been 30 certain. The persons who came down with me were so pleased that they said were she established to run periodically they would never go in anything else."

The following rates were charged to various points from New York: Newburgh, $3, 14 hr.; Poughkeepsie, $4, 17 hr.; Esopus, $4.50, 20 hr.; Hudson, $5, 30 hr.; Albany, $7, 36 hr. In Renwick's life of Fulton, in addition to the foregoing rates, these details are given:

> All other way passengers to pay $1 for 20 miles passage and a half dollar for each meal.
>
> Children between 1 and 5 years, one-third price if sleeping with those having charge of them.
>
> Young persons between 5 and 13 years, half price sleeping two in a berth; full price sleeping one in a berth.
>
> Servants, two-thirds price for one in a berth; one-half price for two in a berth.
>
> Each passenger paying full price was allowed 60 lb. of baggage; if less than full price, 40 lb. of baggage. For surplus baggage 3 cents a pound was charged.

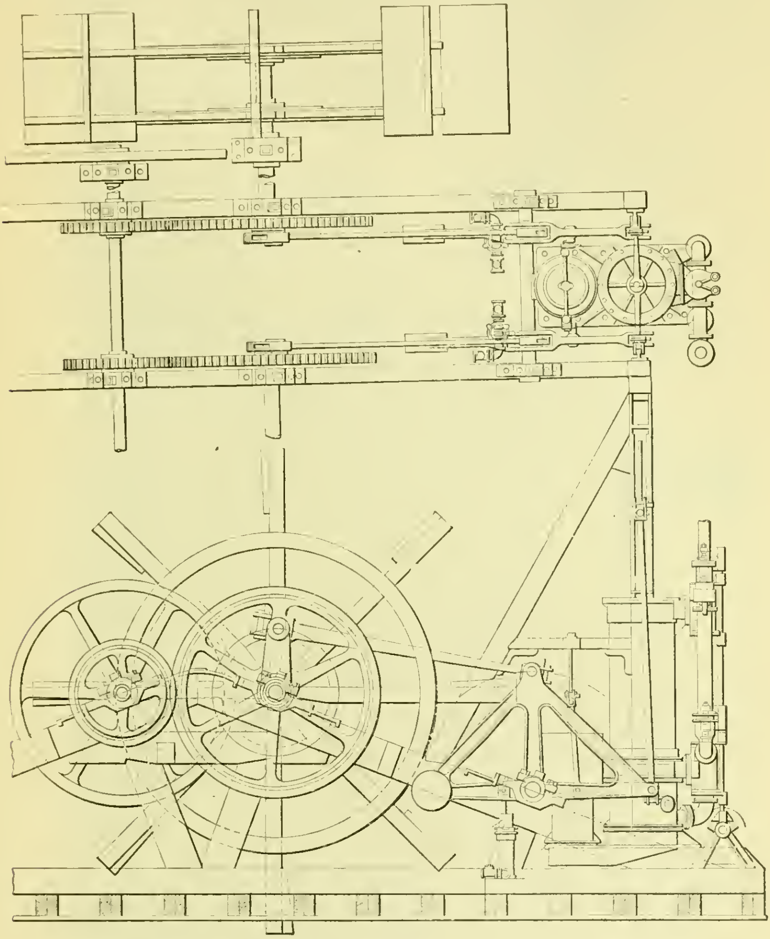
There is evidence that the regular trips of the Clermont were made under some difficulties, for the North River sloops, perhaps seeing in the Clermont the beginning of successful competition for their freight and passenger traffic, sought opportunities to run afoul of her and damage her paddles. Fulton was obliged to construct guards for the paddlewheels, but one writer states that the spirit of



Plan of the Clermont's Engine from Fulton's Patent Specifications

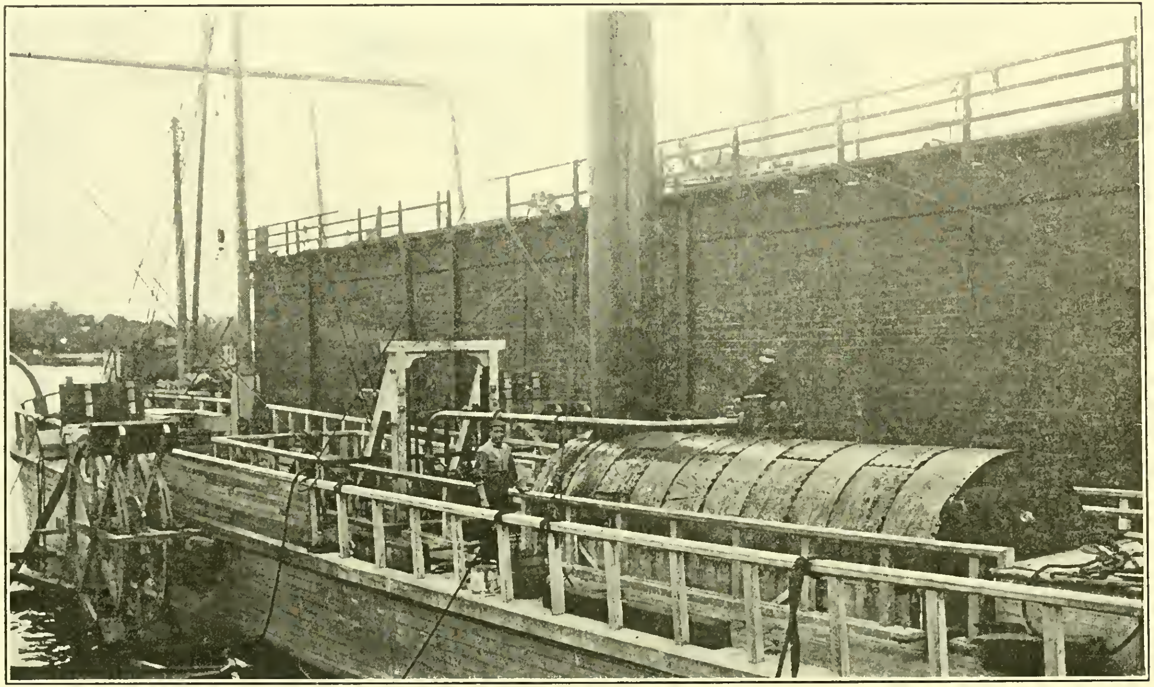
hostility became so strong that the Legislature passed a law to punish any person who attempted to injure the boat.

The Clermont made several trips during the fall of 1807 at stated times advertised in the newspapers. During the winter extensive alterations were made to provide passenger accommodations and in the spring of 1808 the Hudson River trips were resumed. At some time her name was changed to North River. Under favorable conditions the journey to Albany was made in twenty-eight hours at the rate of six miles an hour. Sometimes one hundred passengers were carried.



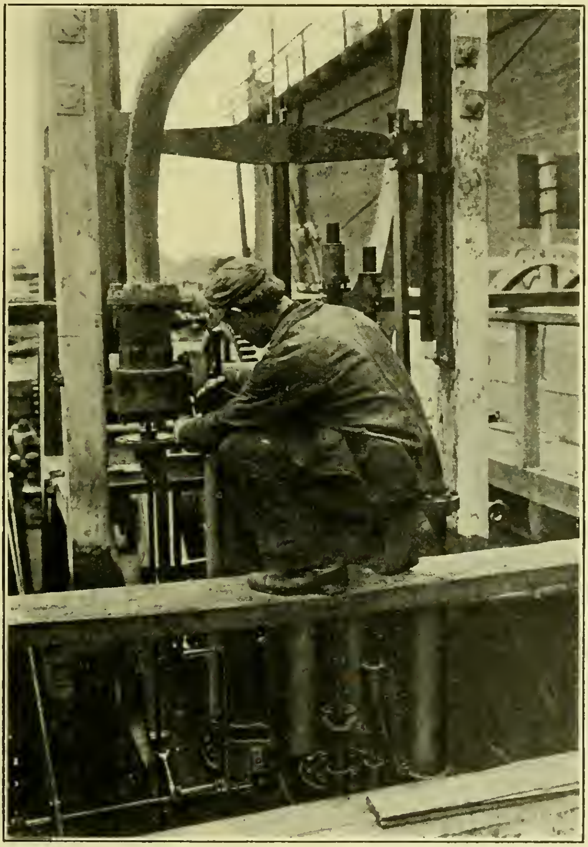
Plan and Elevation of the Engine in the Clermont II

Not long after the maiden trip of the Clermont, probably some time in 1808, repair shops were built at North Point, Jersey City, the equipment including the first drydock in the United States, measuring 200 ft. long, 36 ft. wide and 16 ft. deep. Here Fulton built the machinery for his third boat, Car of Neptune, launched in the fall of 1809.



View from the Stern, Showing Boiler, Stack, Crosshead Guide and Paddle Wheel

After the Clermont, the vessels built by Fulton were as follows: Rariton,—it was so spelled at that time—spring of 1809; Car of Neptune, fall of 1809; Paragon, 1811; a Hudson River ferryboat, 1811–12; an East River ferry boat, 1812—the floating ferry docks or bridges were also designed by Fulton; Camden, 1812; Richmond, Washington, Fulton, ferry boat Nassau, 1813; Vesuvius, 1814. In December 1814 Fulton contracted with the Government for the employment of the steamboats Vesuvius, Etna, New Orleans, Natchez and Buffalo as transports on the Mississippi and Ohio Rivers. How many of these had been completed at that time is not known. The Chancellor Livingston was not completed until after Fulton's death in February 1815. The first steam frigate, first called Demologes and later Fulton the First, was designed by Fulton and launched in



View of the Engine, Showing Throttle Valve, Steam and Exhaust Lines and Part of the Valve Gear

1814. She was not completed until after Fulton's death and was subsequently used as a receiving ship at the Brooklyn Navy Yard.

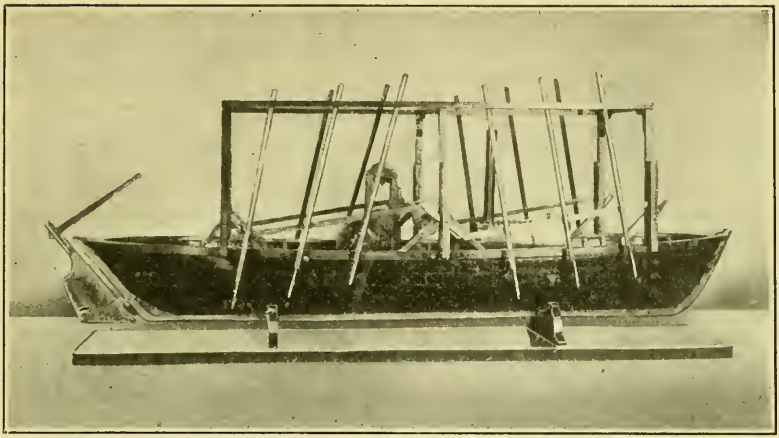
It is said that John Stevens began his work in steam navigation in 1791, having received an inspiration from viewing the trial of one of Fitch's boats. In 1798, a steam-propelled vessel was tried on the Passaic River. The New York Legislature was petitioned by Stevens for a monopoly of steam navigation but the petition was not granted.

In 1804 a 68-ft. boat, 14 ft. wide, fitted with a single-screw propeller, was built by Stevens and in 1805 a twin-screw boat was launched on the North River. The machinery of this boat was afterward placed in a larger boat, the Phoenix, 103 ft. 3 in. long, 16 ft. wide and 6 ft. 9 in. deep, which was launched on April 9, 1808, at Hoboken. In a statement given by John Stevens to the New York Evening Post of October 20, 1808, he says that on one of her trips the Phoenix left Hoboken on September 27 at 12.30 p.m. and owing to delays in adjusting the machinery, strong head winds and a heavy swell, did not reach Perth Amboy till 7.15. The next morning she left Perth Amboy at 12.30, arriving at Hoboken at 6 p.m., having sailed 30 miles in 5 hr. 35 min., or more than 5½ miles an hour. It is stated by some writers that the Phoenix made the sea voyage to Philadelphia during the summer of 1808, but the foregoing statement by Stevens shows that the trip could not have been made until later.

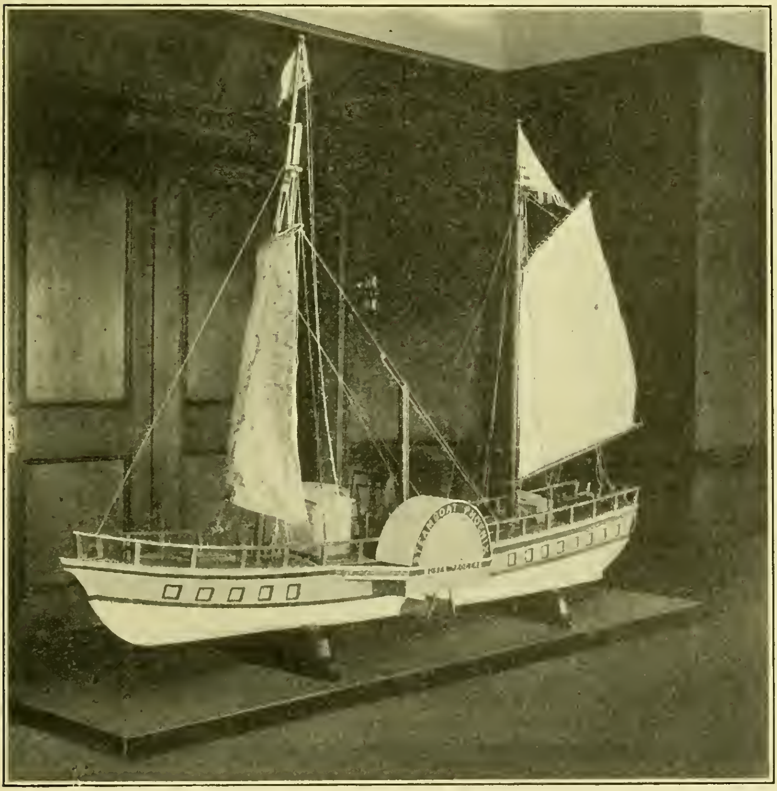
In the spring of 1809 the Phoenix made a number of trips between New York and New Brunswick, a distance of 37 miles in 9½ hr. including stops. However, as the New York Legislature had granted Fulton a monopoly of steam navigation and as the nearly completed Rariton, Fulton's second boat, was intended for operation over this course it was decided to sail the Phoenix to the Delaware River by way of the Atlantic. She left New York on June 8, 1809, arriving at Philadelphia on June 17. Thus was accomplished the first sea voyage of a steam-propelled vessel.

Judging from the models the lines of the Phoenix were much superior to those of the Clermont. The engine also shows greater simplicity. The Phoenix ran as a passenger boat on the Delaware, stopping at Philadelphia, Bordentown and Trenton, where connection was made with stages across New Jersey to New Brunswick, one of the terminals of the Rariton. After running for a number of years over this route the Phœnix was wrecked at Trenton in 1814.

The model of John Fitch's steamboat represents one built in Philadelphia in 1786, a successful public trial being made on the Delaware River, on July 27 of that year. The length was 34 ft.;



Model of John Fitch's Boat Built in Philadelphia and tried on the Delaware River in 1786



The Phoenix, built by John Stevens. In 1809 she made an Ocean Trip from New York to Philadelphia width 8 ft.; depth, 3 ft. 6 in. It was equipped with a steam engine, which, connected by geared machinery, sprocket wheel and chain, operated oars placed vertically in a frame on each side of the boat.

In 1788 Fitch completed his first commercial boat for carrying passengers, and it was driven in a similar manner. This boat was 60 ft. long and 8 ft. wide. In July 1788, a trip was made from Philadelphia to Burlington, about 20 miles, the longest ever made by any steamboat up to that date. On October 12, 1788, the boat carried 30 passengers from Philadelphia to Burlington in 3 hr. 10 min., a speed of over six miles an hour. In 1791 Fitch built another boat, which attained a speed of eight miles an hour, and continued to run on the Delaware River, carrying passengers and freight, for three or four months. In 1796, another boat was built by Fitch and tried on the Collect Pond in New York. It is said that this boat was fitted with a screw propeller.

Fitch was not able to obtain sufficient financial backing for his experiments and was therefore unable to develop further his ideas of steam navigation.

PERSONALS OF THE MEMBERSHIP AM. SOC. M. E.

Walter C. Allen, formerly general superintendent of the Yale & Towne Manufacturing Company's plant at Stamford, Conn., has recently been appointed general manager of that company with headquarters in New York.

F. C. Armstead, supervising engineer of the stoker department of the Westinghouse Machine Co., for a number of years located at East Pittsburg, now has his headquarters at the Westinghouse Works, Attica, N. Y.

Dickerson G. Baker, formerly consulting engineer, Samuel M. Green, Inc., has accepted the position of works manager, Blake & Knowles Steam Pump Works, East Cambridge, Mass.

A. Bement has been appointed by Governor Deneen delegate to represent the State of Illinois at the American Mining Congress at Goldfield, Nev.

Wm. A. Bole has been appointed assistant manager of the works of the Westinghouse Machine Co., E. Pittsburg, Pa., with particular jurisdiction over the Trafford Works.

Chas. J. Caley has resigned as general manager of the Russell & Erwin Mfg. Co., because of ill health. He is still a member of the board of directors and later it is expected will act in an advisory capacity.

Wm. T. Donnelly has been appointed official representative of the Manufacturers' Association of Brooklyn on the inspection trip to the Adirondacks under the auspices of the State Water Supply Commission. This trip is being made to inspect the available water supply with regard to power, storage and flood conditions.

Ralph E. Flanders is the author of a book on Gear-Cutting Machinery.

Frank A. Haughton has become associated with the Taylor Iron and Steel Co., High Bridge, N. J.

Clarence H. Helvey has accepted a position with the Hamilton Engineering Co., Hamilton, O. He was until recently in the service of the Power Equipment Co., New York.

An illustrated article on The Manufacturing Laboratory at Neubabelsberg, by Henry Hess, was published in the September 9 issue of *The American Machinist.*

H. A. S. Howarth has contributed an article on Simple and Automatic Stop-Pins for Press Work, to the September issue of *Machinery.*

Mark L. Ireland, who was recently stationed at the Watertown Arsenal, Watertown, Mass., will be relieved from the Ordnance Department, U. S. A., and return to the Coast Artillery Corps, Fort Stevens, Ore., after October 5.

Louis L. Johnson, formerly in the employ of the Westinghouse Machine Co., Chicago, Ill., has been appointed gas engineer of the electrical department of the Southern Pacific Co., San Francisco, Cal.

Wm. A. Jordan has become associated with the Charles Warner Co., Wilmington, Del. He was formerly connected with Stephen T. Williams. and staff in the capacity of industrial engineer.

Prof. R. R. Keely, and A. G. Robb have been elected to the council of the Nova Scotia Society of Engineers.

William F. Lee, formerly engineer for the C. W. Hunt Co., New York, has entered into partnership with C. J. Roelker of Richmond, Va. They will do general engineering work throughout the South, under the firm name of Roelker and Lee.

Jas. G. Maclaren has been transferred from the home office of the Lamson Consolidated Store Service Co., at Boston, Mass., to look after engineering work in the New York department.

A biographical sketch of Melville W. Mix was published in the September number of *Cassier's Magazine*.

Curtis C. Myers, has resigned as mechanical engineer of the Diamond Chain and Manufacturing Co., Indianapolis, Ind., to accept the position of shop coördinator in coöperative engineering courses at the University of Cincinnati.

Robt. W. Rogers is now connected with the Erie Railroad, with headquarters in the general mechanical superintendent's office at Meadville, Pa.

A. H. Sabin has been elected a fellow and member of the honorary council of the North British Academy of Arts and Sciences.

Robert Shirley has been appointed works manager of the Chapman Valve Mfg. Co., Indian Orchard, Mass. Until recently he was associated with the Pratt & Cady Co., Hartford, Conn., as mechanical engineer.

Chas. H. Speer has entered the service of the Algoma Steel Co., Ltd., Sault Ste. Marie, Ont., in the capacity of assistant engineer. He was formerly consulting engineer with Carr & Speer, New York.

H. L. Watson has been transferred from the Cleveland office to the Boston office of the Allis-Chalmers Co.

NECROLOGY

WILLIAM THOMAS REED

William Thomas Reed, Mem.Am.Soc.M.E., was born June 27, 1847, London, England. He received his education at the Commercial College, Kent, and entered railway service in 1862 as a machinist; was apprenticed to the London, Chatham & Dover Railway, 1869–1871; became a machinist on the Grand Trunk Railway, Canada, in 1871, afterwards serving the road as leading machinist, at Stratford, Ont., 1875–1877, foreman erecting and other shops, at Montreal, P. Q., 1877–1883; locomotive foreman, at Belleville, Ont., 1883–1887.

In 1887 he became master mechanic of the Western division, Canadian Pacific Railway; and from 1888 to 1894, acted as general master mechanic, St. Paul & Manitoba Railway. From 1895 to 1898 he was superintendent of the Chicago Great Western Railway, and from 1893 to 1901, superintendent of motive power and machinery, Seaboard Air Line Railway, Portsmouth, Va. He was locomotive superintendent for the Jamaica Government Railway, from 1902 to 1906, at which time he was appointed locomotive superintendent of the Gold Coast Government Railway, West Africa. He held this position until 1908, when he received another appointment on the Jamaica Government Railway. In 1890 he became a member of this Society.

Mr. Reed died of malarial fever, July 1, 1909, only a few hours after leaving Kingston wharf on leave of absence, and was buried at sea.

ARCHIBALD W. BLAIR

Archibald W. Blair, Jun.Am.Soc.M.E., died July 17, 1909 at the home of his father, Dr. W. W. Blair, in Princeton, Ind., where he was born June 4, 1865. He was a graduate of the Princeton High School and took a special course in mechanical engineering at Purdue University. After serving an apprenticeship in the foundry, machine, boiler and smith shops of the Princeton Foundry and Machine Works, Mr. Blair went in 1890 to Cincinnati where he attained high standing as a mechanical draftsman. At the time of his death he was chief draftsman of the American Laundry Machinery Company and also instructor in the Ohio Machinists' Institute, and a member of the American Association of Engineers. He was a man of many excellent traits and high attainments and will be greatly missed by his associates. Mr. Blair entered the Society as a Junior in 1898.

TAN BARK AS A BOILER FUEL

By David Moffat Myers, New York
Associate Member

It is the object of this paper to give the chief characteristics of wet spent tan as a boiler fuel. It is believed that tan bark contains a larger percentage of moisture than any of the other moist fuels. It is perhaps safe, therefore, to assume that its correct treatment as a fuel may indicate to a certain extent the most efficient means of dealing with other moist fuels.

2 The writer has been engaged in testing, remodeling, operating and constructing steam plants depending partly or principally upon tan bark for their fuel; and in connection with this work the following tests and observations were made, not only to determine the value of the fuel, but principally to indicate the most favorable conditions for its complete combustion and to improve the economy of the plants visited.

PHYSICAL CONDITIONS

3 The nature of tan bark is too well known to require minute description, but it may be stated, as relating directly to its use as a fuel, that its condition in the fireroom varies with the method of its preparation for leaching, and its treatment in the leaches. Bark which has been finely disintegrated, and has been blown a long distance through a pipe or flue, will reach the furnaces almost in the state of a wet powder, difficult to burn. On the other hand, with less thorough disintegration and a shorter fan drive, the tan will be in larger pieces which allow a freer passage to the draft. The tan in the fireroom varies in temperature according to its final treatment in the leach house and according to the distance it is conveyed from the leach to the furnaces. Under good conditions it often reaches the fireroom at a temperature of 110 deg. fahr. The amount of moisture

To be presented at a meeting of The American Society of Mechanical Engineers. All papers are subject to revision.

in the tan varies with the leaching process and usually runs from 62 to 70 per cent. Oak tan is easier to burn than hemlock because it is harder and does not become soggy and pack on the grates, but admits the draft more freely than the hemlock.

CALORIMETER TESTS

4 The calorific tests given in Table 1 were made by Dr. Henry C. Sherman of Columbia University, the samples of tan being dried before burning.

TABLE 1 CALORIFIC VALUES OF DRIED SPENT HEMLOCK TAN

Sample No.	B. t.u. per Pound	Sample No.	B. t.u. per Pound
1	9406	7	9519
2	9378	8	9450
3	9463	9	9504
4	9500	10	9850
5	9516	11	9472
6	9482	Average.......	9504

Note—Samples 7, 8 and 9 each contained about 6 per cent of oak tan.

EFFECTS OF LEACHING

5 Calorific tests were made to determine the effect of leaching on the fuel value of the tan, and it was found that the percentage of tannin left in the bark does not affect its calorific value per dry pound. As a check a further test was made, comparing a sample of leached bark and one of unleached bark. The result showed only a slight difference of heat units between the two and in fact a trifle more heat in the leached bark per dry pound. In other words it can be stated that the degree of leaching to which tan bark is subjected does not affect its fuel value, except inasmuch as actual weight is subtracted by the leaching process, so that a smaller quantity of fuel reaches the fireroom.

6 As regards the loss of weight due to leaching, 100 lb. of air-dry bark fed to the mill will produce 74.7 lb. of tan in the fireroom under good leaching conditions. This tan contains 65 per cent moisture, e. g., 100 lb. of air-dry bark ground at the mill will result in about 213 lb. of spent tan, containing 65 per cent moisture, in the fire-room; i. e., the weight of the spent tan is 2.13 times the weight of the bark ground.

MOISTURE

7 Ten of these samples contained moisture varying from 63.6 per cent to 68.27 per cent, the average moisture being 65.5 per cent. Many more moisture tests were made, but these ten samples are typical and represent about the average conditions in this respect. Taking the average calorific power of dried hemlock tan at 9500 B.t.u., and the average moisture at 65 per cent, and calculating the loss due to moisture, we have: Loss by moisture = $0.65[(212° - t) + 966 + 0.48\ (T - 212°)]$. For t we have the temperature of the moist fuel = 100 deg., and for T the temperature of the flue gases, which in tan burning averages about 500 deg. Substituting these values gives:

Moisture loss = $0.65\ (212 - 100) + 966 + 0.48(500 - 212) =$ 660 B.t.u.

8 Since a pound of fuel is 65 per cent moisture, 0.35 lb., or the dry amount, must evaporate 0.65 lb. moisture. The calorific value of 0.35 lb. of dry tan is 0.35 of 9500 B.t.u., or 3325 B.t.u., which is the total B.t.u. in a pound of moist fuel. Subtracting the moisture loss we have 3325 B.t.u. – 660 B.t.u. = 2665 B.t.u., as the available heat in a pound of fuel as fired.

TAN BARK COMPARED TO COAL

9 As previously deduced, the weight of the bark as ground × 2.13 = the weight of the spent tan. Therefore the available heat for boiler purposes obtained from a pound of average air-dry hemlock bark is 2.13 × 2665 B.t.u. = 5676 B.t.u. As compared to coal of 13,500 B.t.u., 1 ton of hemlock bark ground at mill = 0.42 tons coal.

CHEMICAL ANALYSIS

10 The chemical composition of dry tan is as follows:

	Per cent
Mineral ash	1.42
Hydrogen	6.04
Carbon	51.80
Oxygen	40.74
	100.00

This sample was hemlock tan containing 6 per cent oak tan. When dried at 110 deg. cent., it lost 66.77 moisture.

EVAPORATIVE TESTS

11 The actual evaporative power of tan was taken from the results of 22 complete boiler tests burning tan alone. Eight of these were thermal-efficiency tests.

12 Four complete thermal-efficiency tests were also made using both tan and coal for fuel. The above tests were conducted in accordance with the Am. Soc. M. E. code, and in different parts of the country, including the South, the East and the Middle West. The type of boiler in every case was the horizontal tubular. The furnaces varied considerably in design and economic results; but they were all of the Dutch oven type, set in front of the boiler; and all were fired from the top through feed-holes, with the exception of the furnace designed by the writer, the results and design of which will be described later. All the above tests were made under natural draft. Tables 2 and 3 show one of the 24-hr. boiler and furnace efficiency tests, selected to show what may be considered ordinary conditions and results in tan burning.

13 By designing and constructing a special furnace for the purpose the writer obtained a thermal efficiency of furnace and boiler of 71.1 per cent, burning hemlock tan, efficiency based on available heat of fuel. The principal features of this furnace, which was sub-

TABLE 2 BOILER TEST "X" TANNERY

Data and Results of Evaporative Test on Boiler No. 6 to Determine Horsepower Developed and Efficiency of Existing Methods and Conditions for Burning Wet Spent Hemlock Tan as Fuel for Steam Generation.

Kind of fuel	Wet spent hemlock tan
Kind of furnace	Wide high oven, 2 rows firing eyes
Method of starting and stopping test	Alternate
Grate surface, square feet	92
Water heating surface, square feet	2089
Heating surface ÷ grate surface	22.7

TOTAL QUANTITIES

Date of trial	November 5 and 6, 1902
Duration of trial, hours	24

Weight of tan as fired, pounds	53,000
Percentage of moisture in tan	65.6
Total weight of dry tan consumed, pounds	18,232
Total weight of water fed to boiler, pounds	69,825
Factor of evaporation	1.1216
Equivalent water evaporated into steam from and at 212 deg., pounds	78,316

HOURLY QUANTITIES

Wet tan consumed per hr. pounds	2208
Dry tan consumed per hr., pounds	1823
Water evaporated per hr., pounds	2909
Equivalent evaporation per hr., from and at 212 deg., pounds	3263

AVERAGE TEMPERATURES, PRESSURES, ETC.

Steam pressure by gage, pounds	70.25
Temperature feed-water entering boiler	126.5
Temperature escaping gases from boiler	471
Force of draft between damper and boiler, inches water	0.39
Temperature outside air	64
Temperature of tan as fired	83

HORSEPOWER

Horsepower developed	94.6
Rated horsepower, at 15 sq. ft	139
Percentage rated horsepower developed	68

ECONOMIC RESULTS

Water evaporated under actual conditions per lb. tan as fired, pounds	1.32
Equivalent evaporation from and at 212 deg. per lb. tan as fired, pounds	1.48
Equivalent evaporation from and at 212 deg. per lb. dry tan, pounds	4.30

EFFICIENCY

Calorific power of dry tan per lb., British thermal units	9463
Percentage moisture in tan as fired	65.6
Available heat in 1 lb. of wet tan as fired, after subtracting loss due to evaporating moisture, British thermal units	2443
Efficiency of boiler including furnace, based on available heat in fuel, per cent	58.2
Efficiency of boiler including furnace, based on total heat in fuel, per cent	43.9

FIRING

2 rows of eyes, 3 eyes in each row. Eyes were fired according to regular method employed at this tannery, i. e., they were refilled as they burned low, a large amount of tan being fired each time. 51 eyes were fired during the 24-hr. test.

TABLE 3 FLUE-GAS ANALYSIS

Damper Wide Open

No.	Time	CO_2 %	O %	CO %	Firing
1	9 : 45	10.8	7.5	....	30 minutes after
2	10 : 21	4.2	12.3	....	30 minutes after
3	11 : 48	11.5	7.0	....	14 minutes after
4	12 : 29	5.0	15.0	....	22 minutes after
5	1 : 37	4.6	15.1	0.5	While firing
6	2 : 06	5.0	13.0	0.3	14 minutes after
7	3 : 05	9.2	....	....	40 minutes after
8	4 : 08	9.8	8.4	....	While firing
9	5 : 30	12.6	6.6	0.1	5 minutes after
10	6 : 20	12.6	7.0	0.5	26 minutes after
11	6 : 55	11.6	7.4	0.2	25 minutes after
12	7 : 50	13.0	6.0	0.6	20 minutes after
13	8 : 55	13.0	7.2	0.1	While firing
14	10 : 09	11.0	9.1	...	6 minutes after
15	11 : 07	12.5	6.9	0.1	29 minutes after
16	12 : 23	11.5	7.5	0.8	23 minutes after
17	1 : 07	7.6	11.8	1.1	67 minutes after
18	2 : 10	12.5	7.7	0.0	24 minutes after
19	2 : 50	6.0	13.5	...	20 minutes after
20	4 : 00	4.3	15.7	...	58 minutes after
21	5 : 30	3.0	16.4	0.3	While firing
22	6 : 02	11.0	8.8	0.0	27 minutes after
23	6 : 37	9.0	9.8	0.0	6 minutes after
24	7 : 35	8.7	11.0	0.2	9 minutes after
Average	....	9.2	8.2	0.32	

sequently installed in a number of plants, were: *a* Large combustion space over the burning fuel. *b* Automatic stoking with rotating comb shafts. *c* Oppositely inclined grate surfaces converging downward to a set of shaking and dumping grates. *d* Drying on dead plates over which fuel passed before receiving air supply. *e* Concentrated draft from opposing grate surfaces to a focus of combustion, caused by parallel spacing of longitudinal flat grate bars with beveled edges. *f* Reverberating draft action resulting from concentrated draft-currents and the curvature of the arch, thus directing flames back upon dead plates. The full results of a test on this furnace are given in Table 4.

EFFECT OF PRESSING AND BURNING MIXED WITH COAL

14 It was desirable to learn the exact economic effect of burning coal with pressed tan and also the result of pressing the tan to eliminate some of the moisture. For these purposes three thermal-

TABLE 4 BOILER TEST AUTOMATIC STOKER FURNACE DESIGNED BY THE WRITER

Data and Results of Evaporative Test on Boiler No. 1 to Determine Horsepower Developed, and Efficiency of Boiler with Automatic Tan Stoker

Kind of fuel	Wet spent hemlock tan
Kind of furnace	Automatic stoker
Method of starting and stopping test	Alternate
Grate surface, square feet	61.5
Water heating surface, square feet	1795

TOTAL QUANTITIES

Date of trial	August 14, 1903
Duration of trial, hours	12
Weight of tan as fired, pounds	18,600
Percentage moisture in tan	65.3
Total weight of dry tan consumed, pounds	6449
Total weight of water fed to boiler, pounds	33,004
Factor of evaporation	1.085
Equivalent water evaporated into steam from and at 212 deg., pounds	35,809

HOURLY QUANTITIES

Wet tan consumed per hr., pounds	1550
Dry tan consumed per hr., pounds	537
Water evaporated per hr., pounds	2750
Equivalent evaporation per hr. from and at 212 deg., pounds	2984

AVERAGE TEMPERATURES, PRESSURES, ETC.

Steam pressure by gage, pounds	43
Temperature feed-water entering boiler	155
Temperature inside furnace	1100
Temperature in combustion chamber	1475
Temperature gases escaping from boiler	493
Temperature outside air	71
Temperature of air entering ash pit	78
Temperature of tan as fired	101
Force of draft between damper and boiler, inches water	0.4

HORSE POWER

Horsepower developed	86.5
Rated horsepower of boiler at 15 sq. ft., per h.p.	120
Percentage rated horsepower developed	72.1

ECONOMIC RESULTS

Water evaporated under actual conditions per lb. of tan as fired, pounds	1.77
Equivalent evaporation from and at 212 deg. per lb. of tan as fired, pounds	1.93
Equivalent evaporation from and at 212 deg. per lb. of dry tan, pounds	5.55

EFFICIENCY

Calorific value of dry tan per lb., B.t.u	9850
Percentage of moisture in tan as fired	65.33
Available heat per lb. of tan as fired, B.t.u	2623
Efficiency of boiler, including furnace, based on available heat in fuel, per cent	71.1
Efficiency of boiler, including furnace, based on total heat in fuel, per cent	54.4

FIRING

Firing was even and continuous with automatic stoking. Bed of fuel maintained on grates was about 9 in. thick.

TABLE 5 FLUE GAS ANALYSES

Damper Open

No.	Time	CO_2 %	O %	CO %
1	2 : 25	11	7.5	0
2	4 : 30	12.8	5.6	0
3	7 : 15	12	7.8	0
4	9 : 05	13	6.2	0
5	11 : 10	13	6.4	0
Average		12.4	6.7	0

TABLE 6 ANALYSIS OF SPENT BARK

Chemist's No. S.-736, Analyzed August 17, 1903

	%		%
Moisture	65.33	Non-tannins	2.35
Total solids	5.11	Available tannin	1.89
Total soluble solids	4.24	Reds	0.87

efficiency tests were conducted, all on the same boiler and furnace, the conditions as far as possible being the same in all tests, and the furnace operated by the same firemen. The furnaces and boiler were of the general type already referred to. The combustion chamber under the boiler differed by having a system of air admission through the bridge wall. The opening in the wall for admitting air to this system was set $\frac{1}{4}$ open in the first test and remained so in all three tests, each of ten hours' duration. An effort was made in each of the two tests without coal to equal the boiler output of the test in which coal was used; but as shown below this could not be done.

15 The furnace arch was equipped with two rows of firing-eyes of three eyes each, and two eyes on the same side of the furnace were usually fired at a time. The firing was heavy, the cone of tan nearly reaching the arch each time after firing. The furnace had a grate surface of 11 ft. 4 in. by 7 ft. 0 in. = 79.3 sq.ft., and the perpendicular distance from the grate surface to the highest point of the arch inside was 48 in. The boiler was 6 ft. by 18 ft. and contained 2089 sq.ft. heating surface, the ratio of heating surface to grate surface being 26.3 to 1.

TABLE 7 COMPARATIVE RESULTS OF THREE TESTS

	Test No. 1	Test No. 2	Test No. 3
Thermal efficiency of boiler including furnace, based on available heat in fuel, per cent	63.4	59.4	59.
Evaporation from and at 212 deg. per lb. tan as fired, pounds..........................	1.98	1.90	1.65
Evaporation from and at 212 deg. per lb., dry tan, pounds.............................	5.43	4.71	4.54
Percentage rated h.p. developed	135.5	92.	72.4
Type of furnace................................		wide and high	
Heating surface ÷ grate surface	26.3	26.3	26.3
Number of firing-eyes..........................	6	6	6
Depth of combustion chamber, inches............	48	48	48
Kind of firing.................................	deep	deep	deep
Firing intervals, minutes.......	18.8	18.8	19.4
Kind of fuel	pressed tan and coal	pressed tan	unpressed tan
Moisture in tan, per cent......................	60.4	59.6	63.6
Steam pressure, pounds	76	74	63.4
Temperature feed-water	163	160	161
Flue temperature......	561	486	445
Force of draft in uptake, inches water	0.51	0.49	0.43
Duration of trial, hours.......................	10	10	10
Flue-gas analyses, averages per cent CO_2........	13.8	10.9	10.5
Per cent O	4.9	7.8	8.6
Per cent CO	0.15	0.93	0.68

16 Nine flue-gas analyses were made during test No. 1, seven in each of the following tests, and the averages of these results are given in Table 7 which gives the most essential results of the three tests.

17 The results of this series of tests show:

a That the burning of coal with pressed tan increased the thermal efficiency from 59.4 per cent to 63.4 per cent.

b That the burning of coal with pressed tan increased the boiler output from 92 per cent of rated capacity to 135.5

per cent of rated capacity, the force of draft differing by only 0.02 in. water-gage.

c That the degree of combustion as indicated by the amount of CO_2 was raised from 10.9 per cent CO_2 with pressed tan to 13.8 per cent CO_2 with pressed tan and coal.

d That the flue temperature was increased from 445 deg. with unpressed tan and 486 with pressed tan to 561 deg. with pressed tan and coal.

e That the thermal efficiency based on available heat obtained with pressed tan was 59.4 per cent as compared to 59 per cent with unpressed tan.

f That the burning of pressed tan gave a boiler output of 92 per cent rated capacity as compared to 72.4 per cent with unpressed tan, the draft being only 0.04 in. water-gage stronger in the test of greater capacity.

g That since the thermal efficiency was practically the same with both pressed and unpressed tan the principal advantage of pressed over unpressed tan in this particular case lies in the intrinsically greater calorific value of the pressed tan owing to its reduced moisture. In this particular case, in which the unpressed tan contained 63.6 per cent and the pressed tan 59.6 per cent moisture, the actual gain in available heat-units was 4.5 per cent over the unpressed tan or 1⅛ per cent gain in heat value for each per cent decrease in moisture.

TAN PRESSES

18 Tan presses for reducing the moisture in actual practice result in a total economic gain of only about 7 per cent; and against this must be charged the power to run them, maintenance, repairs and often the disadvantage of noise and vibration in the fireroom.

19 The question of installing a press must be determined principally by local conditions, such as amount of tan available, amount and proportion of coal used and its cost, intelligence of labor, average moisture in the tan as delivered to the fireroom, design of furnace and grate, cost of changing such design, etc. Especially when the firing is poor a press is of much value, for certain firemen who can get excellent steaming with pressed tan cannot raise steam with unpressed tan. When a press is introduced for tan burning and the moisture is reduced, the rate of combustion with given grate and draft

is increased. Therefore to burn the pressed tan in the time required to burn the wet tan, it is necessary to reduce the grate surface proportionately.

20 For example, two complete 24-hr. evaporative tests were made on the same boiler and furnace, with the same firemen and with the same conditions as nearly as possible, the first with unpressed and the second with pressed tan, with the following results:

Test No. 1, without press, 64.4 per cent moisture, consumption 14,565 lb. dry tan with 0.42 draft.
Test No. 2, with press 60.4 per cent moisture, consumption 19,879 lb. dry tan with 0.38 draft.

Thus the rate of combustion on the same grate was increased 36.5 per cent. (It may here be noted that the boiler-horsepower developed in the first test was 89.3 h.p., and in the test with pressed tan 116.8 h.p.)

21 Therefore in this case to burn the tan in the same time as formerly it would be necessary to reduce the grate surface about 27 per cent. This is based on the above drop in moisture from 64.4 percent to 60.4 per cent, or 4 per cent. The drop in moisture with fair pressing will run between 6 and 7 per cent, representing a total gain of available heat of 7 to 8 per cent. With good pressing the grate surface may be properly reduced one-third.

22 There have been cases of failure with pressing the tan simply because the precaution of reducing grate surface was not taken. Tannery superintendents have said, "We have tried presses and had to throw them out, because the tan would not last throughout the day, and we had to use more coal to make up the deficiency." The point here is that a tannery will almost invariably consume or waste every pound of steam its boilers will supply. With the press in operation the steaming was increased proportionately as long as the tan "lasted," no provision being made to correct the grate surface, and consequently the result would be exactly as stated by the superintendent. This has led to, or confirmed, the erroneous opinion held by some that the moisture in tan aids its combustion.

EFFECT OF SMALL COMBUSTION SPACE OVER THE FIRE

23 A special test on a low-arched furnace was made to obtain comparison with high arches. A furnace containing nine feed-holes,

and having a height from arch to grate of 26 in., was tested, with the results shown in Table 8.

TABLE 8 RESULTS OF TEST ON LOW-ARCHED FURNACE[1]

Efficiency of boiler and grate, per cent	26.4
Evaporation from and at 212 deg. per lb. tan as fired	0.63
Percentage rated h.p. developed	39
Heating surface ÷ grate surface	28
Depth combustion chamber under boiler	3′6″
Intervals between firing, minutes	6.3
Kind of tan	Hemlock
Percentage moisture in tan	67.2
Temperature flue-gases	422
Draft at damper, inches	0.37

24 These miserable results are to be attributed to the low arch and the consequently inadequate combustion-space between the fuel and the arch of the furnace. Owing to this small space the velocity of draft and gases was very high, thus removing the volatile fuel-gases from the furnace before their combustion could be fairly begun, and allowing no heating or mixing action in the furnace, and when they struck the boiler the combustion was checked or stopped.

25 The worst evaporative results ever obtained on various designs of higher furnaces, on tan alone and with poor firing are at least 100 per cent better than this, and these other furnaces ran from 3 ft. 0 in. to 5 ft. and 6 ft. high; it is perhaps significant that the highest thermal efficiency was obtained in the furnace with the greatest amount of free combustion space between the fuel bed and the top of the arch.

26 During recent years tanneries have been using more extracts and less bark for their liquors. At the same time a greater amount of machinery has been introduced and it has been found beneficial to use more heat in leaching. All these changes have resulted in greater steam requirements and less spent tan bark for its generation. Therefore more coal is required in the boiler room and stricter economy of fuel is necessary.

BURNING A MIXTURE OF TAN AND COAL

27 Among other methods of burning the two fuels, the ordinary coal-burning setting has been tried. The grates are usually of the shaking variety and are set directly under the boiler, and generally only 24 in. to 30 in. beneath the shell of the boiler. The coal and tan

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[1] Average flue-gas analyses: CO_2, 4.3 per cent; O, 11 per cent; CO, 20 per cent.

are fired alternately by hand. Owing to the large volume of tan as compared to its heating value (spent tan weighs about 33 lb. per cu. ft.) the fire doors have to be opened very often, thus admitting a great excess of cold air to the fire. The fire bed has a strong tendency to burn through in spots and form blowholes. The temperature-retaining effect of the Dutch oven arch is lost, and instead, the fuel gases come into direct contact with the shell of the boiler, which cools them before combustion is fairly under way. The result of every such case the writer has observed has been a dull, smoky fire of greatly varying temperature and never good combustion. In a certain plant where this method was thoroughly tried out, it proved so unsuccessful that it was discontinued and the grates were replaced by Dutch ovens in which the mixture of tan and coal was burned, the fuels being mixed before firing.

28 The above illustration affords a good comparison of combustion with and without a brick arch over the fire bed with hand firing, and goes to show that a brick or refractory arch is a necessity for good combustion, when the two fuels are so related in quantity that their heat values are about equal. As a further demonstration, experiments with automatic stoking may be cited. The mixed fuel was fed into a chain-grate stoker operating on induced draft. This was done under the most favorable conditions possible and under the supervision of an engineer representing the chain-grate company, with the assistance of the writer. The steam pressure and the furnace temperature dropped rapidly, and it was soon necessary to eliminate the tan and feed coal alone, to prevent the fire from going out. Experiments with different methods of mixing and feeding the two fuels all resulted in killing the fire.

29 Like experiments were conducted on a Detroit stoker set in front of boiler and having a brick arch completely over the fire. No scientific tests were conducted, but the mixed fuel easily carried the load formerly carried by the coal, it being necessary only to increase the speed of the stoker. The steam pressure was increased and as far as the eye could detect there was not the slightest decrease of furnace temperature, the combustion being clear and to all appearances excellent.

30 From these experiments it seems entirely safe to state that for efficient combustion of a mixture of tan and coal in ratio by weight of 5.2 to 1 a refractory arch over the greater part of the fire, and preferably over the entire fire-bed, is not only advisable but necessary. It follows that tan bark of the usual moisture and heat content can-

not be burned without the application of a refractory arch, or some device of similar function, such as a large combustion chamber lined with refractory material.

31 Wood is sometimes burned in combination with tan in the same furnace. Good results are obtained when the wood is ground to about the same fineness as the tan, when it is known in the sawmill districts as "hog feed." When wood in slab or log form is burned in the same furnace with tan the results naturally are usually very poor, owing to blowholes formed in the fire bed and consequent large excess of air. A case of this description came under the writer's observation. "Edgings" from a nearby sawmill cost less than coal per 1000 B.t.u., and it was the custom to fire the edgings by hand into the front fire doors of the tan furnaces, the tan being fired from above in the usual manner. A large amount of labor was required and the furnace fronts required constant repairing. By substituting coal for the wood in this case, and mixing with the tan before firing, a very good saving was effected in fuel, labor and repairs.

32 In regard to draft for tan burning, in 26 evaporative tests on tan-burning furnaces the average force of draft between boiler and damper was 0.45 in. water gage.

33 The average draft, in 13 tests on tan where less than the rated capacity of the boiler was developed, was 0.42 in. water gage between boiler and damper.

DRAFT AND GRATE SURFACE

34 The average draft, in 12 tests on tan where rated capacity up to 60 per cent over-capacity was developed, was 0.47 in. water gage. This comparison is significant only in a very general way, owing to the great variety of ratios of heating to grate surfaces in the different tests, and the different methods and time intervals of firing. The highest force of draft found in any case between damper and boiler with chimney draft, furnaces burning tan only, was 0.63 in., and the lowest 0.32 in.

35 The lightest draft with which rated capacity was obtained was 0.32 in., and in this case the ratio of heating surface to grate surface was 21.8 to 1. In the test where 160 per cent rated capacity was developed the force of draft was 0.51 in. and the ratio of heating surface to grate surface was 19.3 to 1. The greatest ratio of heating surface to grate surface which developed full rated capacity was 29.9 to 1, giving 110 per cent rated capacity with force of draft in uptake

0.42 in. The firing in this case was excellent with intervals of 7.4 min.

36 Owing to space required, facility in cleaning fires, minimum radiation from furnace and expense of building and repairing, it is desirable to make the furnace grate area as small as possible and still conform to capacity requirements. It is therefore necessary to know the boiler-horsepower developed per square foot of grate surface. The force of draft, method of firing and ratio of heating surface to grate surface, are all factors in this result, also the moisture in the tan bark. Table 9 gives the most important factors with results of nine actual tests.

TABLE 9 RESULTS OF NINE TAN-BURNING TESTS

Test No.	Tan	Moisture %	Draft Inches	H.S. / G.S.	Firing Intervals Minutes	B.H.P. per sq. ft. G. S.
1	Oak	0.53	0.63	29	15	2.35
2	Hemlock	....	0.51	19.3	8	2.07
3	Oak	0.64	0.58	29	5	2.37
4	Oak	0.64	0.61	34.8	....	1.53
5	Hemlock	0.65	0.61	17.4	50.8	0.92
6	Hemlock	....	0.32	21.8	5.2	1.51
7	Hemlock	0.68	0.39	29.9	7.4	2.34
8	Hemlock	0.64	0.42	22.7	30	0.97
9	Hemlock	0.65	0.40	29.2	Continuous	1.31

37 Inspection of this table shows that one factor above all the others influences the b.h.p. developed per square foot of grate, and this factor is the method of firing. Thus the tests in which the time intervals between firing are small show a marked increase in b.h.p. per square foot of grate. This test is upheld by many other tests of the writer. From the table we may take the following average results:

For oak tan with 60 per cent moisture, 0.61 in. draft, in uptake of horizontal tubular boiler, and good firing of 15 min. or less between firing, 2.08 b.h.p. per sq.ft. of grate surface.

For hemlock tan with 65½ per cent moisture, 0.44 in. draft in uptake of horizontal tubular boiler, and good firing of say 17 min. or less between firing, 1.52 b.h.p. per sq. ft. of grate surface.

GRATE SURFACE FOR COAL AND TAN

38 The above results are for burning tan alone. At the present time, however, it is very general practice, as previously set forth, to burn coal with the tan. The best results in most cases are obtained when the coal is mixed evenly with the tan, and the mixture burned in a Dutch oven with shaking and dumping grates. This practice modifies the boiler-horsepower per square foot of grate. The grate surface often allowed is at the rate of about 3¼ b.h.p. per sq. ft. of grate surface, the ratio of heating surface to grate surface ranging from 50 to 1 to 33 to 1.

TABLE 10 RESULTS OF TESTS OF BURNING COAL WITH TAN IN DUTCH OVENS

Test	Tan	Grates	Tan Moisture %	Uptake Draft	H. S. G. S.	Firing Intervals Minutes	Weight of Coal to Weight of Tan as Fired	B.H.P per sq. ft. of Grate
a	Hemlock	Shaking	68	0.40	33.5	20	1 to 8.9	2.52
b	Hemlock	Stationary	60.4	0.51	28.1	19	1 to 6.1	2.53
c	Hemlock	Stationary	66.7	0.67	37.3	6.3	1 to 46.4	2.70
**d*	Oak	Shaking	67.4	0.7	29.4	47	1 to 2.9	2.66
e	Hemlock	Stationary	66.5	1.05	32.8		1 to 22.8	1.33

*Tubular Boiler, coal fired independently in front doors of double arched tan furnace. The 47-min. interval refers to the tan only.

39 Of course, as with tan alone, the development per square foot of grate depends upon the same factors, with the additional factors of the proportion of coal mixed with the tan, and the B.t.u. and character of the coal. The figures in Table 10, selected at random, show the results in terms of b.h.p. per square foot of grate surface obtained in actual tests of burning coal with tan in Dutch ovens. It is of interest here to note that when the ratio of weight of coal to weight of tan as fired is 1 to 5.2, then the heat developed by each fuel is practically the same. This is figuring on 13,000 B.t.u. coal, and "tan as fired" containing 2500 B.t.u. available heat, which is good average value.

40 In further reference to draft, a test which showed excellent results was made on a plant operating on induced fan draft. A small proportion of coal was used in the tan furnaces and a thermal efficiency of 66.1 per cent was found under regular working conditions, the CO_2 in the flue gases averaging nearly 12 per cent. The writer has also observed an oak tan burning furnace operated temporarily on fan

draft with closed ashpit. The combustion was apparently very good; a hot fire was maintained, but additional care was required to keep blow-holes from forming on the grates.

41 A reliable report has also been obtained on the installation of a steam-induced forced-draft system, applied under the grate of a tan-burning furnace. According to the report, the steam used for the draft condensed on the grate bars, with low temperature due to contact with the large mass of wet tan, and the concern that made the installation after considerable experimenting removed the appliance and gave up tan burning.

GRATES

42 Grates for tan burning are made in different patterns, but usually contain from 20 per cent to 30 per cent air space, the actual opening between the bars being $\frac{3}{16}$ in. to $\frac{1}{4}$ in. Larger spaces than these allow the tan to fall through into the ashpit. A shaking grate is hardly necessary for burning tan alone, owing to the small percentage of ash. No clinker is formed, only a very fragile crust on the grate obtains in three or four hours. In some cases fires are cleaned only once in 12 hrs. with good results. Unlike a coal fire, a tan fire should be shaken or disturbed very little. If a slice bar is used on a brightly burning tan fire, dense smoke results and the flame is killed for some time.

43 The temperature in the throat of a properly designed tan furnace, burning tan alone, will reach 1500 deg. fahr.

44 The depth of fuel on the grate varies with the design of the furnace and the method of firing. In ordinary practice the tops of the cones of tan directly beneath the firing eyes vary from 2 ft. to 5 ft. above the grate surface, while the depth of tan where the cones meet will be from 6 in. to 18. in., depending on the design and firing of the furnace.

45 When spent hemlock tan forms a cone from the conveyor-discharge on the fireroom floor it forms an angle of slide of about 55 deg. to the horizontal. Inside a hot furnace, however, this angle is about 45 deg., and in laying out a tan furnace the latter angle is used in figuring the distribution of fuel on the grate. The angle of slide of tan on a sloping grate is 39 deg. to 41 deg., and these angles were used in designing the automatic tan furnace referred to previously.

46 Among other experiments with this fuel the writer has made

tests to compare results of double settings with single settings. By double setting is meant a setting so arranged that two furnaces discharge their gases into a common combustion chamber beneath two or more boilers. Tests showed no tangible results in favor of either method as regards evaporation or fuel economy. It is possible however to imagine a case where the fire in a furnace might be in poor condition, when if the setting were a double one, the second furnace might maintain in the common combustion chamber a temperature sufficiently high to ignite and burn fuel gases discharged from the dull fire which otherwise would escape unburned. It is the opinion of the writer, however, that owing to the impossibility of laying off a single boiler for cleaning or repairs, a double setting is less desirable than a single setting. Furthermore, good firing and handling would in any case offset any possible advantage of the double setting.

47 The combustion of tan, as indicated by flue-gas analyses made with an Orsat apparatus, compares most favorably with the combustion of coal in factory plants where the same amount of attention is paid to the boiler room. In fact, the percentage of CO_2 runs higher than in the ordinary coal-burning plant. For instance, the average CO_2 of 17 evaporative tests on different tan-burning furnaces was 11.3 per cent; the lowest average CO_2 in any of the tests was 4.3 per cent, which represented unusually and abnormally poor conditions; and the highest average CO_2 in any one of them was 16.9 per cent. The CO averages about 0.5 to 0.6 per cent and ranges from practically zero up to 2 per cent.

SUMMARY

48 The following statements concerning tan bark as a boiler fuel have been demonstrated by the foregoing data and confirmed by constant checking in actual practice:

49 *Moisture.* In condition for firing, wet spent hemlock tan usually contains close to 65 per cent of moisture.

50 *Available B.t.u.* Bomb calorimeter tests on many samples of spent hemlock tan give an average value of about 9500 B.t.u. per lb., sample being dried before burning. The available heat per pound as fired, after subtracting moisture loss, is about 2665 B.t.u.

51 *Ratio weights.* Since the weight of the spent tan in the fire room is 2.13 times the weight of bark ground at the mill, 1 lb. of ground bark produces an available heat value of 5676 B.t.u. Hence,

as compared to coal of 13,500 B.t.u., one ton of hemlock bark is equivalent to 0.42 ton coal.

52 *Effect of leaching on B.t.u.* The heat value of spent hemlock tan is not affected by the degree of leaching, except inasmuch as the actual weight is affected.

53 *Chemical composition.* The chemical composition of hemlock tan (sample containing 6 per cent of oak) was:

$$C = 51.8,\ H = 6.04,\ O = 40.74,\ \text{Mineral ash} = 1.42 \text{ per cent}$$

As a fuel analysis this is of interest as regards the small amount of ash and the large amount of oxygen.

54 *Boiler tests.* The actual operation of tan bark as a fuel is shown by complete boiler tests made under working conditions, records of which are given above.

55 *Improved efficiency.* A considerable improvement in efficiency was produced by a specially designed furnace providing automatic feeding, large combustion space over fuel and special draft admission.

56 *Tan Presses.* The use of presses for reducing the moisture in the tan before firing may be good economy if the amount of tan compared to the amount of coal used is considerable, and providing the grate surface is properly reduced to meet the demands of the more rapid combustion. In practice the grate surface is sometimes reduced one-third on the introduction of tan presses.

57 Under usual tan-burning conditions the total gain in available heat from the use of a press is about 1⅛ per cent for each per cent drop of moisture content, and this drop rarely exceeds 7 per cent, i. e., a reduction of moisture from say 65 to 58 per cent.

58 The writer is of the opinion that the combined boiler and furnace efficiency would naturally rise considerably when tan presses are used, owing to increased furnace temperature and better combustion, although as shown by Table 7 the thermal efficiency was raised only from 59 per cent to 59.4 per cent, the moisture in the tan being 63.6 per cent and 59.6 per cent in the two tests respectively. This may be explained, at least partially, by the fact that the grate surface was not reduced for burning the pressed tan.

59 *Addition of coal.* As a result of special comparative tests, made under similar conditions on the same furnace and boiler, the addition of about one pound of coal to six of pressed tan increased the combined furnace and boiler thermal efficiency from 59.4 per

cent to 63.4 per cent. The addition of coal also resulted in raising the average CO_2 in the flue gases from 10.9 to 13.8 per cent. The percentage rated capacity of the boiler was increased from 92 per cent (without coal) to 135.5 per cent with coal.

60 Although the above precise statements were obtained from a single pair of accurate tests, the writer's subsequent experiences in many plants confirm the results as generally typical; and it may be safely stated that under usual working conditions the addition of coal to tan produces a decided increase in degree of combustion and a consequent rise of thermal efficiency. The increase of boiler output attending the use of coal with tan is also a factor of economy not to be disregarded.

61 *Ample combustion space.* One of the most important factors, in designing furnaces for tan-burning, is that of ample combustion space. In usual tan-burning practice this means a high arch over the furnace. Low-arched furnaces are conducive to bad combustion, whereas furnaces providing an arch at a considerable height above the fuel on the grates give decidedly better combustion and higher efficiency. (See tests and discussion, par. 23 *et seq.*)

62 *Refractory arch.* A refractory arch or similar combustion arrangement is necessary for the economic combustion of tan. Tan in its usual condition cannot be burned in a common coal-burning setting without an arch separating the fire from the cooling surface of the boiler shell or tubes. Even when tan is enriched with coal to a point where the two fuels form equal heating values (about 1 lb. coal to 5.2 lb. wet spent tan) good combustion cannot be obtained in an ordinary coal setting. This holds true both for hand-firing and automatic stoking. (See tests and discussion, par. 27 *et seq.*)

63 *Draft.* The force of draft required in general practice for tan burning is somewhat higher than that required for producing the same boiler output with bituminous coal. No definite figures can be given for force of draft as related to tan burned per square foot of grate surface, owing to the widely varying designs of furnaces and methods of firing. It may be stated, however, that for full capacity not less than ½-in. draft should be provided for in the uptake of a horizontal tubular boiler, when the boiler is set so that the gases flow under the shell and through the tubes directly to the stack or breechen.

64 *Horsepower per square foot of grate.* The boiler-horse power obtainable per square foot of grate surface, depending upon the rate of combustion of the tan, is an extremely variable quantity; but aver-

aging the results of nine typical boiler tests it may be said that under usual conditions for oak tan the boiler-horsepower per square foot of grate is about 2.08; and for hemlock tan, 1.5 boiler-horsepower per square foot of grate is an average figure. As demonstrated by results of tests given in Table 9, the one factor which above all others influences the boiler output per square foot of grate is the method and comparative excellence of the firing, very short firing-intervals producing the higher output results.

65 *Horsepower with coal and tan.* When coal is burned in the same furnace with the tan the development per square foot of grate varies of course with the richness of the mixture and with the other usual conditions, and it is best in designing furnaces for any particular plant to use the results of tests made under similar conditions. In four cases out of five selected at random the boiler-horsepower per square foot of grate was 2.5 to 2.7.

66 *Draft area and air spacing.* Grates for tan burning provide 20 to 30 per cent draft area and the spacing is from $\frac{3}{16}$ in. to $\frac{1}{4}$ in.

67 *Clinker and ash.* Tan forms no hard clinker, only a light fragile crust, and a very small amount of ash (less than 1½ per cent based on dry matter), and a shaking grate is unnecessary except when coal is fired with the tan.

68 *Furnace temperature.* Excellent combustion of tan has given a temperature of 1500 deg. fahr., in the throat of the furnace.

69 *Single vs. double setting.* As a result of comparative tests made on single vs. double settings for tan burning, the writer believes that the single setting should have the decided preference. A possible though not a decided improvement in combustion is sometimes obtainable with the double setting, but this is more than offset, especially in the small plant, by the advantages of convenience for cleaning, repairs and adaptation to load given by the single setting.

70 *Use of wood with tan.* When wood is used as a supplementary fuel to tan and fired in the same furnace, the best results are obtained by first grinding the wood to the size known as "hog feed." The firing of wood in log or slab form is disastrous both to the furnaces and to combustion.

71 *Flue gas analyses.* Basing comparison on flue gas analyses, tan burns with a higher combustion than coal, under equally favorable conditions. The large amount of moisture in the tan produces a comparatively low furnace temperature, even with good chemical combustion, and acts against an equally high combined efficiency of furnace and boiler.

72 The highest thermal-efficiency test obtained gave 71.1 per cent efficiency (on boiler and furnace, based on available heat in tan), and flue-gas analyses during this test averaged 12.4 per cent CO_2. The approximate relation of CO_2 to efficiency as obtained under actual running conditions is shown by the curve, Fig. 1, which was plotted from seven thermal efficiency tests made on various designs of furnaces burning tan alone. The figure given at each point plotted is the temperature of the escaping gases during the test.

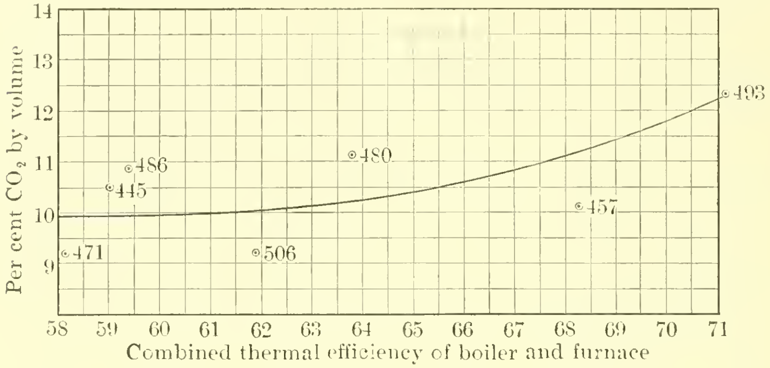

FIG. 1 CURVE SHOWING RELATION OF CO_2 TO EFFICIENCY IN TESTS ON TAN ALONE

THE BEST FORM OF LONGITUDINAL JOINT FOR BOILERS

By F. W. Dean, Boston, Mass.
Member of the Society

It has been generally accepted in this country for a number of years, that the best form of butted longitudinal riveted joint for boilers is that in which the inside strap is wider than the outside, and has one or more rows of rivets which pass through the shell and the inside strap beyond each edge of the outside strap. The pitch of the first row of outer rivets is double that of the rows that pass through both straps, and if there are other outer rows they may or may not have a still greater pitch.

2 In England, where until comparatively recently boiler construction has been superior to ours, this form of joint appears to receive no recognition. It was first devised, as far as I know, by Dr. E. D. Leavitt, Past-President of the Society, and Edward Kendall, both of Cambridge, Mass., and was first used by Mr. Leavitt in some locomotive type boilers designed by him for the Calumet & Hecla Mining Company. I have a blueprint of this boiler dated 1879. It is, of course, hazardous to state that this joint was never used before and it is quite possible that it was used in England, discarded and forgotten as poor construction, as I believe it is. It was first used on an American locomotive by the Baldwin Locomotive Works in a consolidation locomotive built by them for the Calumet & Hecla Mining Company, the drawing of this joint having been made by me when I was in Mr. Leavitt's employ.

3 While every boilermaker has for years been familiar with butt joints, this form made slow progress towards adoption in this country. One form of joint used to avoid the butt joint and get something as good was a lap joint with an inside strap bent at the edge of the lap

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To be presented at a meeting of the American Society of Mechanical Engineers. All papers are subject to revision.

and riveted on each side of it. This was used on locomotives exclusively, and was of little or no value as it was simply a somewhat elastic bent tie connecting the two parts of the shell plate. Finally, and fortunately, this joint gave way to the butt joint first described.

4 I believe there has been no case of an explosion of a butt-joint boiler; at least one due to rupture of the joint. Recently, however, a boiler at Woonsocket, R. I., narrowly escaped explosion, a longitudinal rupture of the plate on one side of the joint, and within its limits, being discovered while the boiler was subjected to steam pressure. The steam pressure was rapidly reduced and no explosion occurred. An account of this is given in Power, January 26, 1909, and the joint itself is in possession of the boiler-inspection department of the Massachusetts district police at the state house in Boston.

5 It has been growing upon me for some years that a one-sided boiler joint, such as that first described, is poor construction, and may sooner or later cause a crack in the plate. The Woonsocket phenomenon has tended to confirm this opinion. It is evident that unless the outside rivets fill the holes they do very little good, and when they do fill them they form an overhung connection and to some extent possess in themselves the now recognized defect of the lap joint. Moreover the extended inside plate forms a bent connection between the different rivets at different distances from the center line of the joint.

6 In many cases designers have placed the outside rivets at a considerable distance from the edge of the outside strap and this is constantly overdone. It is obvious, on careful thought, that the outside rivets should be as near the edge of the outside strap as practicable, thereby diminishing the bent-tie effect. In order to diminish this effect still further, and also to render the overhung rivets more effective, the inside strap should be thicker than usual, and this feature can hardly be overdone. The inside strap should be at least as thick as the shell plate, and great care should be taken to have the holes match and the rivets fill the holes.

7 When a joint of this kind is tested to destruction in a testing machine, it will be found to fail somewhat in detail, the inside strap bending slightly and the outside rivets being the last to rupture after yielding a little. In a boiler the joint would be weaker than a flat specimen on account of the bent-tie feature. This could be prevented if it were practicable to caulk the inside strap as it would thereby be compelled to maintain the circular form. The theoretical efficiency of this joint is greater than of any other kind, but in practice

I believe the efficiency is not realized and the defects that I have described render the joint, in my opinion, undesirable.

8 In order to avoid the defects of the one-sided butt joint, I have adopted and intend to use hereafter, a joint with both straps of the same width, as illustrated in Fig. 1. This has the merit of having all rivets in double shear and the strains all taken care of in the best manner. The efficiency of this joint can hardly be above 84 or 85 per cent while that of the one-sided joint can be theoretically 91 or 92 per cent; but the certainty that the efficiency of the former is realized in practice is ample compensation for the use of slightly thicker plates. The pitch of the outer rows of rivets is rather great, compelling the use of a thick outside strap in order to stand caulking and remain steam-tight. I use an equally thick inside strap in order to diminish the bent-tie effect. This effect is small, however, as the rivets are all near the center of the joint. It can be eliminated by caulking the inside strap, which is practicable with this joint, and is done in the best marine practice. This assumes that the caulking is effective and remains so.

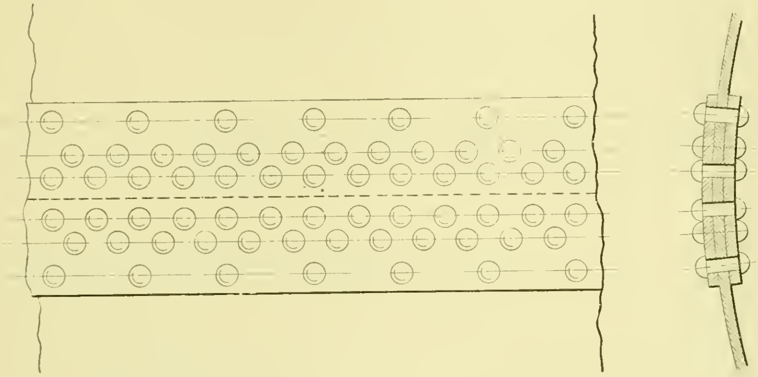


Fig. 1. Recommended Form of Longitudinal Joint

9 While upon this subject, it is well to call attention to the perfection with which the longitudinal joints of boiler-plate cylinders can be welded, as has been demonstrated for many years with corrugated furnaces and more recently with soda digesters. While the joints of corrugated furnaces are in compression those of digesters are in tension, and their proved safety should be sufficient to overcome any timidity concerning the perfection and safety of welded joints. Circumferential are not so easily welded as longitudinal joints, and it is of course of little importance in boilers that they should be welded.

AN EXPERIENCE WITH LEAKY VERTICAL FIRE-TUBE BOILERS

By F. W. Dean, Boston, Mass.
Member of the Society

In 1905 I made a design for a large vertical fire-tube boiler, two of which were built, to be placed on a brick fire box provided with a chain grate. In accordance with a great number of precedents the water leg was short, being in fact 2 ft. deep below the underside of the crown sheet. Unusual provision was made for easy circulation by wide spaces between tubes at every 45 deg. of the circumference instead of the customary 90 deg. or as in some cases at 180 deg. The distance from the top of the grate to the underside of the crown sheet was 7 ft. The following are the general dimensions of the boilers as they now are:

Inside diameter of smallest course of shell	$120\frac{7}{8}$ in.
Inside diameter of largest course of shell	$122\frac{11}{16}$ in.
Inside diameter of water leg	112 in.
Height of water leg	7 ft. $2\frac{3}{4}$ in.
Height of brick furnace	5 ft. 8 in.
Distance from grate to tube plate	12 ft. $2\frac{3}{4}$ in.
Outside diameter of tubes	$2\frac{1}{2}$ in.
Length of tubes	20 ft. 0 in.
Number of tubes	488
Pressure for which the boiler was designed	165 lb.
Kind of grate	B. & W. chain
Size of grate	8 ft. 6 in. by 9 ft. 0 in.
Grate area	76.5 sq. ft.
Water heating surface, say	4900 sq. ft.
Superheating surface	1181 sq. ft.
Total heating surface	6081 sq. ft.

2 The boilers were designed for S. D. Warren & Company and were used in their paper mill at Cumberland Mills, Me. They were built by the Portland Company of Portland, Me. Each boiler was

To be presented at a meeting of The American Society of Mechanical Engineers. All papers are subject to revision.

rated at 500 h.p., or substantially 1 h.p. for every 10 sq. ft. of water-heating surface, and was expected to work at 1000 h.p. a good portion of the time. Artificial induced draft was used and it was possible to obtain a draft of 2½ in. of water in the smoke box.

3 At the back end of the chain grate, instead of a water back or a brick back, a vertical or slightly inclined common grate was used, against which the unconsumed coke would accumulate, and under which the ashes would pass and fall upon the ashpit floor. Difficulty was found in making the coke accumulate uniformly and the ends of this grate were frequently bare.

4 The boilers were started gently and then operated at high capacity. After about two weeks a number of the tubes began to leak at the lower ends. They were expanded, but shortly began to leak again, and this process was repeated until the tubes were so injured that they could not be further expanded. They were then removed and new ends were welded on, but after a comparatively short time they leaked again. The leaks were more on the back half of the boilers than on the front. In winter when a nearby door in the building was open and cold air blew on the vertical grate, when the ends of the grate were bare, the leakage would increase. After learning how to keep the vertical grate covered, and keeping the door closed, the general trouble continued.

5 Knowing the sensitiveness to dirt on the crown sheet of vertical fire-tube boilers, as the design permitted access to the interior, these crown sheets were examined and found to be clean. Thinking that possibly some invisible oil had entered the boilers in some way, one of the boilers was boiled out with caustic soda, but with no effect.

6 The opinions of several boiler experts were obtained, but they differed and were unsatisfactory. One thought that the workmanship was poor, another that the design was the worst he had ever seen. Another thought that the tube plates were too limber and even recommended riveting crown bars to them to stiffen them.

7 Spring Hill coal from Nova Scotia was used at first, followed by New River coal from West Virginia. With the Spring Hill coal the lower ends of the tubes quickly became incrusted with clinker, and were finally closed by it and a little later the clinker would hang in stalactites from the tube ends. Not all of the ends would be closed, but this was the case with a large proportion of them. With New River coal there was less trouble. Spring Hill coal was satisfactory under horizontal boilers and never plastered over the tubes; in the vertical boilers, however, the incrustation was so hard

that it had to be removed with chisels. This incrustation was of course moulten earthy matter injected by the draft against the tubes and tube plate and there congealed by the comparatively low temperature of the metal. In the horizontal boilers it falls to the bottom of the setting before it arrives at the tubes. In water-tube boilers it can be seen adhering to the lower tubes.

8 The existence of this incrustation probably furnishes the explanation of the tube leakage. As a large proportion of the tubes became stopped up the others had to pass all the hot gases, the water about their ends was probably driven away and they became very much overheated, causing them to over-expand, to become upset, and at some later time, when they became cooler, to be loose in the holes.

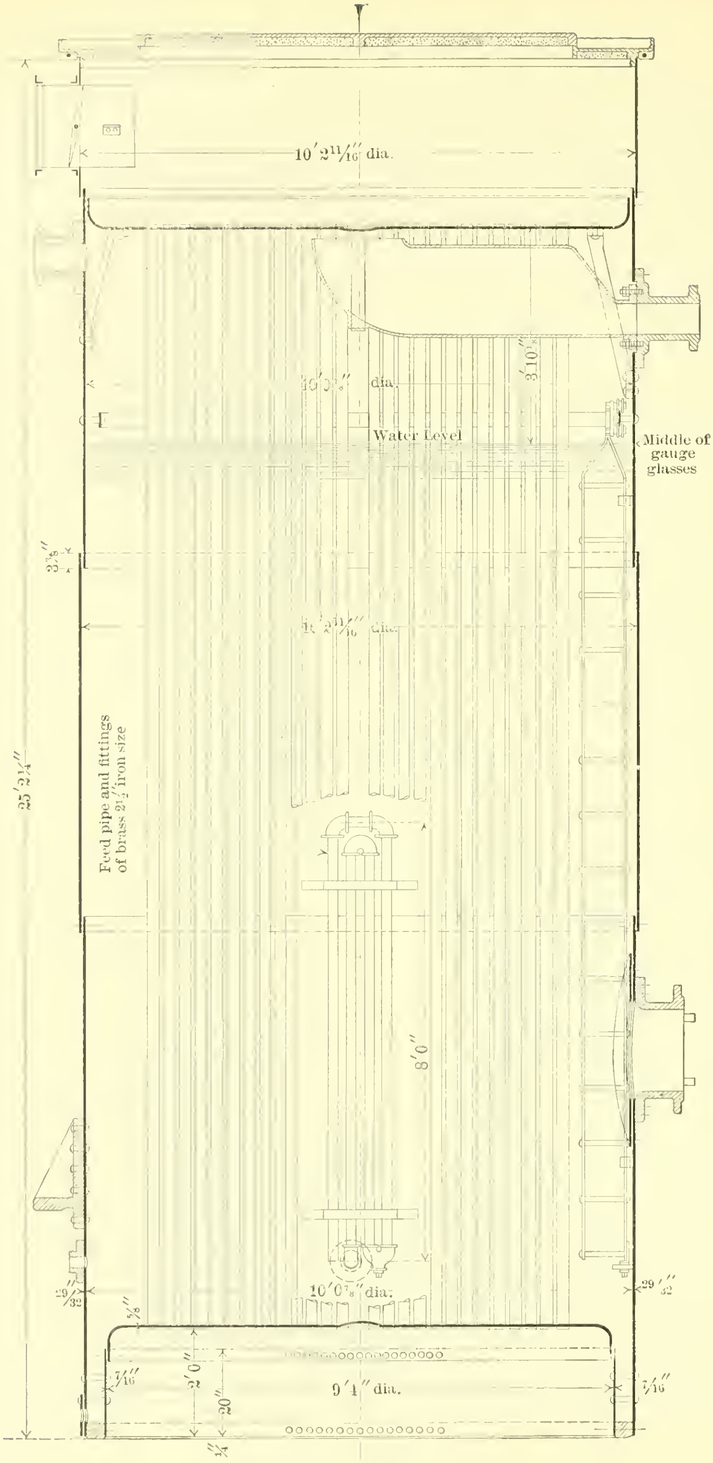
9 As a last resort, when it seemed as if the boilers must be consigned to the scrap heap, someone suggested that to lengthen the firebox and raise the boilers by the amount of the extension might cure the trouble. One boiler was thus altered, started August 31, 1908 and run at the estimated rate of 1100 h.p. 24 hr. per day for some three months, without the slightest leakage, although the tubes were very thin from over-expansion. The other boiler was then altered, and started February 25, 1909. When the first boiler was worked at the estimated rate of 1100 h.p. it consumed 84,000 lb. of New River coal in 24 hr., burning it at the rate of 46 lb. per sq. ft. of grate per hr. Neither boiler has leaked up to the time of presenting this paper.

10 The distance from the grate to the tube plate is now 12 ft. 2¾ in. There is some incrustation, but it is light, brittle and easily crushed, and can be blown off by a rotating multiple tube-blower in the smoke box. The tubes are conveniently and quickly blown in this way every three or four hours.

11 The boiler plant at this mill consists of Babcock & Wilcox boilers, 90-in. horizontal return tubular boilers, and the two vertical boilers described. The latter were intended to reduce the space occupied, both on the floor and above. The rear drum of the chain grate is exposed and the clinker is dropped at the back end, where it is easily removed without inconvenience to the fireman. Above is room for the smoke flues and economizer, which with other types of boiler would have been placed, in this case, with difficulty.

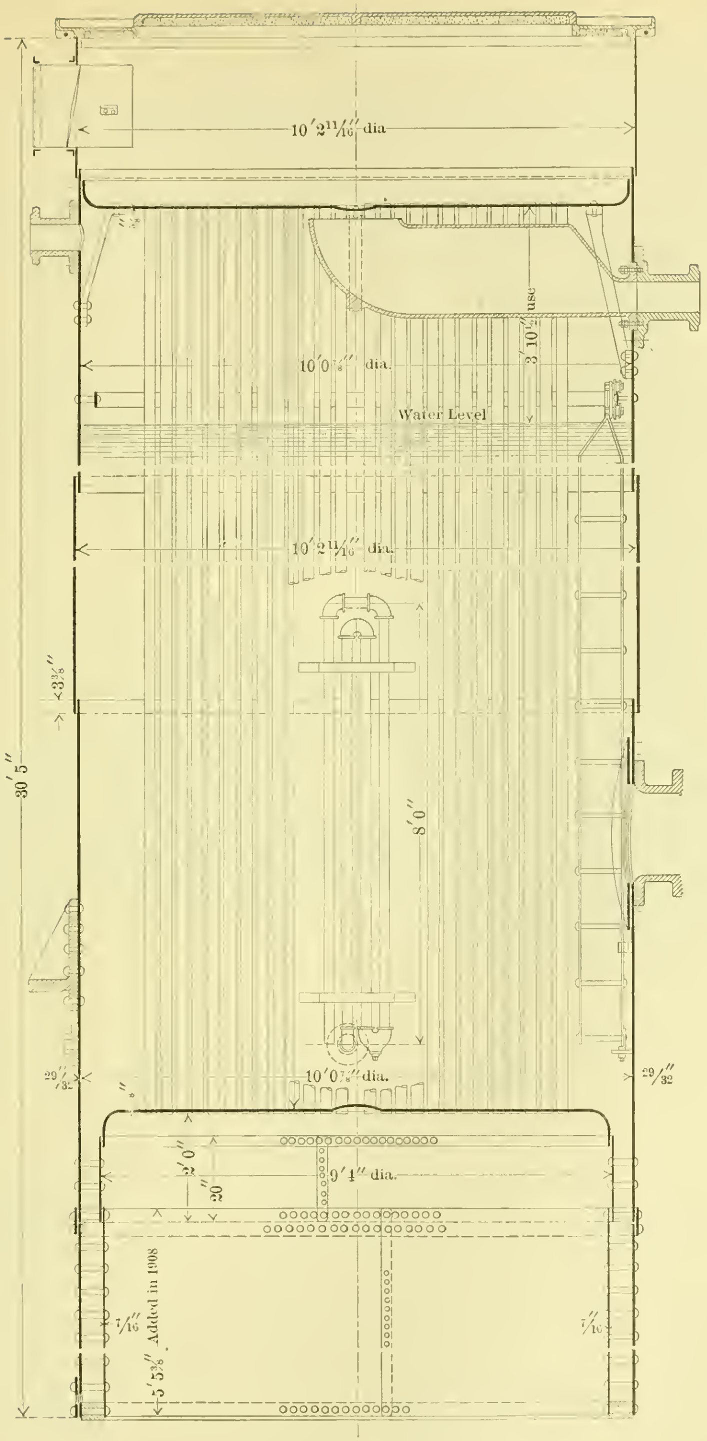
12 After these boilers had been operated long enough to show that they were reliable and a good investment, it was decided to test one of them, with the results given in the tables.

13 While the evaporation is good it is not satisfactory. The function of a boiler is to absorb the heat generated in a furnace. The



BEFORE ALTERATION

Fig. 1 Boiler Before Alteration



AFTER ALTERATION

Fig. 2 Boiler After Alteration

furnace efficiency may be poor and the boiler efficiency good, and that was the case during these trials. The best furnace result occurs when the carbon is burned to CO_2 with as little surplus air as practicable. In these trials the CO_2 was low and some CO was nearly always found. It was impossible to get any better combustion for reasons which I do not know. Experiments will probably be made to ascertain this and overcome the trouble. It might disappear with another kind of stoker.

14 That the boiler efficiency was good is evident from the low temperature of the escaping gases, when developing over 1000 h.p., which is at the rate of less than 5 sq. ft. of water surface per horsepower. It will be noticed that the evaporation was best on combustible when the boiler was operated at double its rated horsepower. It was found impossible to keep the horsepower down to 500. This could only be done by reducing the grate area.

15 An interesting result of the tests is that the superheat was the same at all rates of power.

16 Returning again to the matter of clinker on tubes, it occurs on locomotives which burn anthracite coal, and I understand on locomotives of the Boston & Maine Railroad that burn coke. In the latter case coke-burning locomotives cannot be used on long runs, but whether a better quality of coke would be more successful I do not know. Professor Denton has informed me that clinker accumulated on the boiler tubes of a Transatlantic steamship on which he was a passenger to such an extent that men were sent into the combustion chambers to remove it. He also referred to a Manning boiler on which this trouble occurred.

TABLE 1 TESTS OF BOILERS

Time	Draft	Temperature	CO_2	O	CO	N
April 29, 1909						
8.35– 9.00	0.75	575	7.6	11.2	0.6	80.6
9.05– 9.30	full	575	10.0	9.0	0.3	80.7
9.35–10.00	full	575	7.2	12.2	0.1	80.5
10.05–10.30	full	575	7.0	12.8	0.3	79.9*
10.35–11.00	full	580	7.8	11.2	0.1	80.9
11.05–11.30	full	600	7.0	12.8	0.2	80.0
11.35–12.00	full	620	7.8	11.6	0.1	80.5
12.05–12.30	full	620	8.2	10.7	0.2	80.9
12.35– 1.00	full	610	8.2	11.5	0.5	79.8
1.10– 1.30	full	585	7.7	12.3	0.1	79.9*
1.40–2.10	full	600	8.2	12.3	0.2	79.3
2.20–2.50	full	625	7.4	12.2	0.1	80.3*
3.00–3.25	full	585	7.0	13.3	0.0	79.7
3.35–4.00	full	600	4.8	14.8	0.0	80.4†
4.05–4.30	full	610	7.8	12.0	0.3	79.9
4.35–5.05	full	615	8.3	10.9	0.2	80.6
5.10–5.25	full	640	8.8	10.6	0.4	80.2
5.30–5.50	full	620	8.4			
April 30, 1909						
8.05– 8.30	0.5	575	8.3	11.2	0.3	80.2
8.37– 9.05	0.5	540	8.3	11.1	0.1	80.5
9.15– 9.37	0.5		13.5	5.3	0.8	80.4‡
9.45–10.10	0.4	500	10.7	7.8	0.9	80.6‡
10.20–10.45	0.2	500	10.0	8.7	0.4	80.9‡
11.05–11.30	0.2	510	11.0	7.4	0.6	81.0
11.35–12.00	0.2	520	9.6	8.8	0.8	80.8
12.05–12 30	0.2	525	7.9	11.8	0.2	80.1§
12.35– 1.10	0.2	500	6.7	12.7	0.0	80.6
1.15– 1.45	0.2	525	7.9	12.2	0.2	79.7
1.50– 2.25	0.2	515	7.1	12.5	0.1	80.3
2.30– 3.00	0.2	485	7.0	11.6	0.1	81.3
3.05– 3.35	0.2	520	6.3	13.9	0.0	79.8*
3.40– 4.00	0.2	560	7.4			
May 1, 1909						
8.00– 9.00		520	7.3	13.3	0.0	79.4
9.15–10.00	0.8	525	7.2	12.8	0.0	80.0
10.00–10.55	0.8		5.0	14.5	0.0	80.5
11.05 11.40	0.9	530	7.7	11.6	0.2	80.5
12.45– 1.30	0.7	530	9.0			
1.30– 2.30	0.7	560	8.6	10.4	0.3	80.7
2.40– 3.30	0.7	555	6.0	13.2	0.0	80.8

*Cleaned fire.

†Thin on backside.

‡Fire thick and banked.

§Fire thinner.

TABLE 2 RESULTS OF BOILER TRIALS

Running Start-and-Stop Method of Trial, Vertical Fire-Tube Boiler, New River Slack Fuel

1	Date of trial	Apr. 29	Apr. 30	May 1
2	Duration of trial, hours	7	8	8
3	Number of boilers in use	one	one	one
	DIMENSIONS AND PROPORTIONS			
4	Grate surface 8 ft.6 in. by 9 ft. 0 in., square feet	76.5	76.5	76.5
5	Water-heating surface, square feet	4900	4900	4900
6	Superheating surface, square feet	1181	1181	1181
7	Total heating surface, square feet	6081	6081	6081
8	Ratio total heating surface to grate surface	79.5	79.5	79.5
	AVERAGE PRESSURES			
9	Steam pressure, by gage, per square inch, pounds	129.8	124.3	126.8
10	Atmospheric pressure per sq. in., pounds	14.7	14.7	14.7
11	Absolute steam pressure per square inch, pounds	144.5	139.0	141.5
12	Force of draft in column of water between damper and boiler, inches	1.47	0.28	0.63
	AVERAGE TEMPERATURES			
13	External air	38	35	39
14	Feed-water before entering	50.6	63.6	58.2
15	Escaping gases after leaving	609.1	517.3	558.6
16	Steam	372	369	371
	FUEL			
17	Moist coal consumed, pounds	24,192	17,030	21,782
18	Moisture in coal, per cent	3.06	1.45	4.55
19	Dry coal consumed, pounds	23,452	16,783	20,791
20	Wood consumed, pounds	0	0	0
21	Total dry refuse, pounds	2361	1310	1650
22	Total dry refuse, per cent	10.02	7.8	7.94
23	Total combustible, pounds	21,091	15,473	19,141
24	Dry coal consumed per hour, pounds	3013	1934	2393
	QUALITY OF STEAM			
25	Moisture, per cent	0.00	0.00	0.00
26	Degrees superheated	17	17	17
	BRITISH THERMAL UNITS			
27	Number of heat units in a pound of dry coal, by oxygen calorimeter	14,759	14,759	14,759
28	Number of heat units in a pound of combustible, by oxygen calorimeter	15,760	15,760	15,760
29	Specific heat of superheated steam at constant pressure	0.61	0.61	0.61
30	Heat units absorbed per pound of steam generated	1182	1174	1167
31	Heat units imparted to boiler per pound of dry coal	9901	10,075	9893
32	Heat units imparted to boiler per pound of combustible	11,009	10,929	10,746
	EFFICIENCIES			
33	Efficiency based on dry coal, per cent	67.1	68.3	67.0
34	Efficiency based on combustible, per cent	70.0	69.3	68.2
	FACTORS OF EVAPORATION			
35	Factor of evaporation	1.224	1.215	1.209

TABLE 2 RESULTS OF BOILER TRIALS.—Continued

	Date of trial	Apr. 29	Apr. 30	May 1
	WATER			
36	Total water pumped into boiler, pounds	196,441	144,025	178,250
37	Water actually evaporated, corrected for quality of steam	198,185	145,321	179,854
38	Equivalent water from and at 212 deg. fahr., pounds	242,578	176,633	217,444
39	Equivalent water from and at 212 deg. fahr., per hour, pounds	34,654	22,079	27,193
	EVAPORATIVE PERFORMANCE			
40	Water actually evaporated per pound of dry coal, pounds	8.45	8.66	8.65
41	Equivalent per pound of dry coal from and at 212 deg. fahr., excluding economizer, pounds	10.34	10.52	10.46
42	Equivalent per pound of combustible from and at 212 deg. fahr., excluding economizer, pounds	11.50	11.42	11.36
	COMMERCIAL HORSEPOWER			
43	On basis of 34½ lb. of water from and at 212 deg. fahr., per hour, by boiler h. p.	1005	640	788
44	Heating surface of water surface per horsepower, square feet	4.87	7.66	6.22
45	Horsepower per square foot of grate surface, h.p.	13.14	8.36	10.30
46	Rated horse power	500	500	500
47	Percentage developed above rating	101	28	58
	RATE OF COMBUSTION			
48	Dry coal actually burned per square foot of grate surface per hour, pounds	39.1	25.3	31.3
49	Dry coal burned per square foot of water-heating surface, per hour, pounds	0.61	0.39	0.49
	RATE OF EVAPORATION			
50	Water evaporated per square foot of heating surface per hour from and at 212 deg. fahr., pounds	7.05	4.50	5.55

DISCUSSION AT WASHINGTON MEETING

TESTS ON COMPRESSED-AIR PUMPING SYSTEMS OF OIL WELLS

By Edmund M. Ivens, Published in The Journal for May

ABSTRACT OF PAPER

This paper comprises a brief general description of the compressed-air plants of the various concerns operating on the Evangeline, La., oil-fields, with an explanation of the terms as applied to pneumatic pumping; and deals especially with the systems of pumping formerly used in the oil wells as compared with an improved system which has replaced the earlier ones. A series of tests is given showing the cost of operation, efficiency, etc., of the new and old systems.

DISCUSSION

F. A. Halsey. The air-lift pump is one of those things of which our knowledge is almost exclusively experimental. Its analysis presents such serious difficulties that rational equations for the performance of the apparatus have not been derived by anyone to my knowledge. Under these circumstances, we are reduced to experiment for the determination of the fundamental laws of the performance of the apparatus, and these experiments should cover a wide range in the conditions which lead to variation in the performance of apparatus, namely, depth of submergence and lift.

2 The most complete experiments now on record were presented in a paper before the British Institution of Civil Engineers in 1906,* these experiments being of sufficiently wide scope to supply a satisfactory guide for the design of these pumps under a considerable range of conditions.

3 One curious feature attends the behavior of the air-lift pump and the Taylor hydraulic air compressor, which are essentially the same

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*Abstracted in the American Machinist, August 16, 1906.

apparatus, reversed in action. In each case we have a pair of vertical pipes communicating at the bottom, one filled with water and the other with a mixture of air and water—a sort of suds. If the pipes are of indefinite length the columns will take levels corresponding with their respective gravities, but if the suds pipe is cut off below this level it will overflow, the suds will rise, and we have an air-lift pump: while on the contrary, if the water pipe is cut off below this level, it will overflow, the column of water will rise, and we have a Taylor hydraulic air compressor. The point to which I refer is that while the first of these constructions has a low, the second has a high efficiency. The highest figure given in this paper for the efficiency of the pump is about 28 per cent, and while 40 per cent has been reached in exceptional cases, the average is probably not more than 20 per cent. On the other hand, the efficiency of the hydraulic air compressor is in the vicinity of 75 or 80 per cent.

Dr. Sanford A. Moss. The method used by the author for computation of volumetric efficiency is subject to serious inaccuracies, as he points out. For the purpose of the tests in question, where relative rather than absolute volumetric efficiencies are desired, the method is quite proper. The volumetric efficiencies given must be understood to be relative and not absolute, however, as the errors may be quite serious. I have used the method which the author states he would have preferred for ascertaining volumetric efficiency, Par. 23, and found it very good. Everything operated as would be expected and a reputable value of volumetric efficiency was obtained. In one case, the method as given in Par. 23 was checked by use of calibrated orifices, and also by use of a single tank with rise of pressure, the rate of increase of pressure when the pressure reached the rated value giving the desired volumetric efficiency. All three methods checked very closely. The volumetric efficiency in this case was 58 per cent, showing the serious losses which can occur due to the inaccuracies mentioned.

J. G. Callan.[1] Par. 21 to Par. 23, with diagram (Fig. 7), refer to the method of determining the efficiency of the air compressor, and Mr. Ivens states in Par. 23 the method which he would have preferred for determining this quantity.

2 The method of pumping up pressure in a large tank is open only to the objection that the large tank is rarely obtainable, particularly

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[1] General Electric Co., Schenectady, N. Y.

when the pressures which it is proposed to use are high, and the volume large. A more available and almost equally exact method is afforded by the use of calibrated orifices of which the discharge coefficient has been duly determined. These orifices can be used in connection with well-known formulæ, which involve a knowledge of corrected pressure and temperature of air delivered to orifice, and of velocity and temperature of emergent jet, all factors which can be readily and accurately determined.

3 The losses of a compressor are so considerable and so complex that the assumption of volumetric efficiency from the indicator card may be in error by extremely large percentages and is quite as likely to be misleading as enlightening, unless results are strictly comparative rather than absolute. The value of the present tests would apparently be somewhat affected by the errors in this method of determining delivery, since certain elements of compressor loss would assume different percentage values with different discharge rates.

4 This brings up the desirability of some well-understood standardized method of testing compressors and other apparatus for delivering air. Commercial loss is certain to arise from the considerable variations in terminology and a definition of terms by an authoritative body such as this Society would be of marked advantage. For example, volumetric efficiency undoubtedly should mean the ratio between the air actually discharged (when restored to standard atmospheric conditions of temperature and pressure) to the air which would have been discharged had the compressor cylinder been completely filled on each stroke with air under standard atmospheric conditions, and had all the air displaced been completely discharged. The exact method of determining the approximation of real to theoretical discharge obviously should be only a secondary consideration in such a definition, but could properly be taken up as corollary.

5 The segregation and determination of losses in air compressors of different types form an interesting and useful line of investigation upon which little has been published. A considerable amount of work with which I am familiar indicates that these losses are usually materially greater than the customary assumptions, particularly in compressors which have been in service for some time. Various methods have been devised for independently estimating loss due to heating of intake, leakage of inlet, discharge valves and piston, clearance loss, throttling, and losses due to improper setting of mechanical valve gears, but usually these determinations will involve more labor than a direct measurement of air output by orifice and impact tube.

It is my belief, however, that the computation which neglects all of these losses except the clearance loss, particularly where the pressure is high and the compressor is somewhat worn, is almost sure to be very gravely in error.

THE AUTHOR. The discussions of the paper on oil-well pumping presented at the Washington meeting were centered on the method of ascertaining volumetric efficiency of air compressors. The object of the paper was rather to compare the relative efficiencies of various air-lift systems when being operated on extremely high pumping heads. However, as all the discussions were agreeable to the writer's views and methods, there is no room for argument.

SOME PROPERTIES OF STEAM

By Prof. R. C. H. Heck, Published in The Journal for May

ABSTRACT OF PAPER

Recent information as to the pressure-temperature relation for saturated steam, and the specific heat of water, is presented in this paper. The author summarizes the important work of Holborn and Henning and gives their table in English measures, showing the pressure *p* for each deg. fahr. from 32 deg. to 402 deg.; also the rate of change *dp/dt* derived by him, which is sufficiently exact for effective use in calculating specific volume.

On the subject of the specific heat of water, the author graphically compares the results of Regnault, Barnes and Dieterici, together with the values used by Peabody; and expresses an opinion in favor of Dieterici. He also discusses the relative magnitude of the "mean" heat unit and of that at 15 deg. cent., recommending the use of a conversion factor of the value 0.0011, or 1 in 900, as decidedly preferable to the change in the numerical value of the mechanical equivalent of heat which must accompany the adoption of the mean unit.

DISCUSSION

Dr. Sanford A. Moss. In Regnault's original paper on pressure and temperature of saturated steam was given an empirical formula, first suggested by Roche, but reconstructed by Regnault and called "Formula K." This represented Regnault's results more closely than any other single formula and has also been shown to represent other experimental results, particularly those for very high pressures and temperatures. This formula was discussed by Ramsey and Young in the Philosophical Transactions, Vol. 183, 1892, page 111, and also in London Engineering, Vol. 83, January 4, 1907. I have given some discussion of this matter in the Physical Review, Vol. 25, No. 6, December 1907. It would be interesting if Professor Heck would give a comparison of the values of his table with those computed by this formula. If it can be demonstrated, as is the conclusion in the papers above mentioned, that this formula represents all of the experimental results very closely, it is highly desirable that it be used. Thermodynamic computations can be carried on very readily, if we have a single formula for the entire range.

PROF. G. A. GOODENOUGH.[1] Since the experimental results of Holborn and Henning have been generally accepted, it seems highly desirable to have an analytical relation that will express these results with a sufficient degree of accuracy. For this purpose the formula of Bertrand,

$$\log p = k - n \log \frac{T}{T - a} \qquad [1]$$

seems to be quite suitable. In this formula k, n and a are constants and T denotes the absolute temperature.

2 The values of the constants can be so chosen that the formula will give fair results throughout the ordinary range of temperatures with one set of constants. A closer agreement, however, is obtained by dividing the temperature range into three parts. The values of the constants are:

For $t =$ 32 deg. – 90 deg., $k = 6.23167$, $a = 140.1$ $n = 50$
For $t =$ 91 deg. – 237 deg., $k = 6.30217$, $a = 141.43$ $n = 50$
For $t =$ 238 deg. – 400 deg., $k = 6.27756$, $a = 140.8$ $n = 50$

3 The derivative $\frac{dp}{dt}$ takes the simple form

$$\frac{dp}{dt} = \frac{pna}{T\,(T - a)} \qquad [2]$$

from which follows

$$T\,\frac{dp}{dT} = \frac{pna}{T - a} \qquad [3]$$

This relation is important since the product $T\,\frac{dp}{dT}$ appears in the Clapeyron-Clausius formula for steam volume. Table 1 shows a comparison of the values of p and $\frac{dp}{dt}$ calculated from Formulæ 1 and 2, respectively, with the values obtained by Professor Heck.

4 It will be seen that the maximum difference between the corresponding values of p is about 0.1 per cent. The maximum difference between the corresponding values of the derivative is greater.

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[1] Associate Professor Mechanical Engineering, University of Illinois, Urbana, Ill

COMPARISON OF VALUES OF p AND $\frac{dp}{dt}$

t	p Beck's value	p Bertrand's formula	dp/dt Heck	dp/dt Bertrand's formula
32	0.0886	0.0885	0.003575	0.003588
50	0.1780	0.1781	0.00663	0.006625
75	0.4289	0.4288	0.01425	0.014245
100	0.9462	0.9455	0.02849	0.028575
125	1.9382	1.9387	0.05295	0.052921
150	3.7141	3.7144	0.0921	0.092041
175	6.714	6.711	0.1519	0.15165
200	11.527	11.523	0.2384	0.23843
225	18.913	18.921	0.3591	0.35985
250	29.820	29.834	0.5210	0.52039
275	45.40	45.382	0.7334	0.73248
300	66.98	66.94	1.0035	1.0027
325	96.11	96.07	1.339	1.3390
350	134.51	134.50	1.746	1.7489
375	184.07	184.18	2.231	2.2394
400	246.93	247.20	2.807	2.8167

Evidently this is due to the fact that the values of $\frac{dp}{dt}$ were obtained by Professor Heck (and also by Professor Peabody) by a method involving some approximation; and it is likely that the values calculated from Formula 2 are the more reliable.

5 A great advantage of Bertrand's formula lies in the ease with which it may be used in calculation. This is shown by the following scheme, which is copied from calculations recently made for the engineering experiment station of the University of Illinois:

$t=$	311	312	313	314
$T=$	770.58	771.58	772.58	773.58
$T-a=$	629.78	630.78	631.78	632.78
$\log T=$	2.8868177	2.8873810	2.8879435	2.8885052
$\log T-a=$	2.7991889	2.7998779	2.8005659	2.8012527
$\log \frac{T}{T-a}=$	0.0876288	0.0875031	0.0873776	0.0872525
$50 \log \frac{T}{T-a}=$	4.381440	4.375155	4.368880	4.362625
$k=$	6.27756	....	....	....
$\log p = k - 50 \log \frac{T}{T-a}=$	1.896120	1.902405	1.908680	1.914935
$p=$	78.726	79.874	81.036	82.212
$\log na=$	3.8475727	....	....	....
$\log pna=$	5.7436927	5.7499777	5.7562527	5.7625077
$\log \frac{pna}{T-a} = \log T \frac{dp}{dt}=$	2.9445038	2.9500998	2.9556768	2.9612550

6 In conclusion, it may be stated that Bertrand's formula seems to have a wide range of applicability, and with proper choice of constants can probably be used equally well for nearly all saturated vapors.

The Author. The preparation of this paper was an early step in a special study of the properties of steam upon which the writer has been engaged for some months; the object of this investigation has been to formulate more precisely our knowledge of the subject up to the limit of accurate experiment, at about 400 deg. fahr., and to extend the relations into the higher ranges, even up to the critical temperature. It has been found that Thiesen's formula, by modification of the two coefficients or constants, can be made to fit the Holborn-Henning table exactly from 100 deg. to 200 deg. cent., and that this modified equation holds good up to about 450 deg. fahr. Above that point the curve begins to rise more rapidly, and even crosses the original Thiesen curve. Below 212 deg., the relation can be very exactly extended by means of a small adjustment from the Thiesen values.

2 The formula presented by Professor Goodenough fits the data very well; but for precise calculation it has the disadvantage that at each point of change in constants there will be a break in the curve of the derivative $\frac{dp}{dt}$. The Thiesen formula has a forbiddingly complex expression for its derivative, and would be much less convenient for regular use, if the calculation of $\frac{dp}{dt}$ were an operation to be undertaken frequently.

3 The writer has tried formula K, which is recommended by Dr. Moss. In the very high range it runs low in p, dropping beneath the modified Thiesen formula, which itself is not high enough for the more reliable data.

4 The values of $\frac{dp}{dt}$ in Table 1, found simply by the method of differences, are not precise enough for close work with Clapeyron's equation, the irregularities resulting from the use of them running as high as nearly one-fifth of one per cent. It is the hope of the writer to present to the Society in the near future the results of the special study of the properties of steam mentioned above.

A NEW DEPARTURE IN FLEXIBLE STAYBOLTS

By H. V. Wille, Published in The Journal for January

ABSTRACT OF PAPER

While the ordinary formulæ for flexure do not strictly apply, they have been employed to indicate the magnitude of the stresses in a staybolt. This paper shows that a 1-in. bolt may be stressed to 48,000 lb. per sq. in. and proposes the employment of tempered spring steel in the manufacture of staybolts capable of sustaining this high unit stress. The stem of the bolt is made of tempered spring steel and the ends of soft steel so as to permit riveting over in the boiler. Such a bolt possesses a double advantage in that it is manufactured of material capable of resisting a high unit fiber stress and on account of its small diameter is stressed in flexure to a less extent than the usual type of bolt.

DISCUSSION

William Elmer. The decrease in the diameter of a staybolt, from 15/16 in. or 1 in., which I believe is the present practice, to a small diameter, as 7/16 in., even if the tensile strength of the material is increased, brings to mind at once the possibility of twisting off these small bolts in their mechanical application to the boiler. The writer hopes Mr. Wille will say something about this.

W. E. Hall. Any one who has had the care of the locomotive type of boiler appreciates that staybolt maintenance is a source of intense anxiety, and that the fact that more disastrous results are not forthcoming reflects great credit on the vigilance of the motive power departments of our railroads. This result, however, is accomplished only at high maintenance cost, which, fortunately, has always been of secondary consideration.

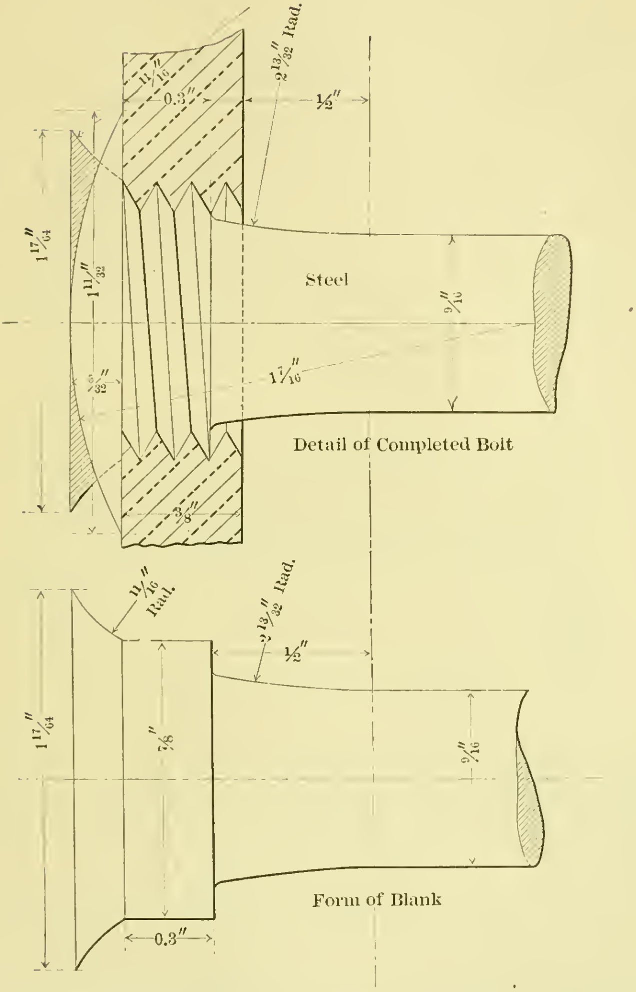
2 Flexibility and length, of which Mr. Wille speaks, no doubt have considerable influence on the breakage of these bolts. It would be

interesting to have details showing the construction of the bolts, and just how they were held, in his vibratory tests.

3 It should be noted, however, that his construction calls for a studbolt of larger diameter than the ordinary staybolt, and in addition this studbolt must project into the leg of the boiler to give sufficient length of thread-contact of the staybolt proper in the studbolt; in other words, he increases the diameter (the studbolt), introduces two threaded surfaces to the strain of flexure, and shortens the staybolt an amount equal to the projection of the studbolt into the leg of the fire-box. Is this not contrary to his own deductions? Assuming that this construction would decrease, but not eliminate, broken staybolts, would this construction facilitate their detection, difficult under the best conditions, or make it more difficult? The reduced length might be relieved by making the fit of the thread of the bolt in the studbolt looser than that of the studbolt in the sheet, thereby always throwing the point of flexure upon the studbolt at the side of the outer sheet. But this is a risky procedure hardly deserving of consideration in boiler practice.

4 The breakage of staybolts is confined almost exclusively to the upper rows of bolts of the legs of the fire-box. The fracture usually starts from the top, sometimes from the side, not infrequently around the circumference and occasionally from the bottom. The fracture is almost always close to the outer sheet, but a break close to the inside sheet is not unknown. The fracture is always in detail, barring shamefully defective material or workmanship, or at least up to the point where the remaining area in contact is not sufficient to withstand the strain to which that reduced area of the bolt is subjected. More or less irregularity of the line of fracture is to be expected. Conditions are not always the same for every bolt: all bolts do not fit the sheets alike, there is more or less variation in the upsetting, and the buckling and warping of the inner sheet is not the same for each bolt. These, together with other minor conditions, representing reasonable refinement in practice, preclude uniformity of the fracture.

5 But the important points are, that these bolts always break in *detail* and always at the *root of the thread.* Have we any reason to expect that it would be otherwise? For example, if we wish to break a piece of metal we first grip it in a vise, notch it close to the jaws of the vise and bend it back and forth. We do the same with a staybolt when we cut the thread with a sharp die (and in this respect the U. S. Standard is inferior to the Whitworth), hold it firmly in the outer sheet and subject it to the bending due to the expansion, con-



Detail of Completed Bolt

Form of Blank

FIG. 1 BLANK AND COMPLETED ENDS OF FLEXIBLE STAYBOLT

traction and warping of the inner sheet. Cutting the thread produces a constructive defect. This feature is necessary as the bolts are now used and its correction is beyond the scope of mathematics.

6 Fig. 1 and Fig. 2 show designs for bolts made in January 1886. The object was to make the bolt of iron or steel and by a gradual reduction from the ends towards the center to make the body of the bolt more flexible; and to make the length of the end such that, after making sufficient allowance for upsetting, the thread could not project beyond the face of the inside of the sheet, thus preventing the thread from being subjected to the strain of flexure. This feature is of the utmost importance. The flare on the end of the bolt was shown merely as a more ready means of upsetting the end, especially when the bolt is of steel. As the number of bolts breaking at the face of the inside sheet is so small as to be negligible, probably still smaller with a more flexible bolt, it would be necessary to control these conditions only at the end in the outer sheet. As this is usually 1/16 in. thicker than the inside sheet, the length of this special end could be readily controlled to prevent the thread projecting beyond the inside face and thereby totally eliminating all bending strain at the root of the thread.

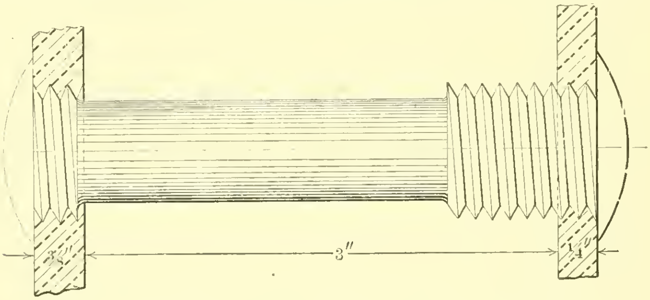


Fig. 2 Flexible Staybolt with End shown in Fig. 1

7 To accommodate the difference in widths in the leg of the firebox the bolts could be made of varying lengths on a bolt machine and kept in stock. More or less variation in the length of the projected threaded area at the inside sheet is not important. By this method, if made by upsetting, it would not be necessary to turn the shank of the bolt. In all lengths, however, the end of the bolt for the outer sheet should be made such that there would never be more than enough for the upsetting and only an additional length of thread sufficient to prevent it from projecting beyond the inside face of the outer sheet.

8 This construction would permit of better circulation on account of less obstruction. It would increase the cost of boiler construction somewhat, but this, with the requirements fulfilled, would be insignificant in comparison with the elimination of the faulty feature and the reduction in maintenance cost.

Alfred Lovell. The durability of staybolts in high-pressure locomotive boilers is a prominent factor in the cost of locomotive maintenance and has an important bearing on the safety of the public. Any innovation intended to increase their durability or reliability is therefore worthy of the most careful demonstration and service trial. The staybolt described by Mr. Wille is of this character, and his paper clearly shows the desirability of providing a staybolt of high elastic limit and great flexibility.

2 This is accomplished by the use of metal having the requisite qualities in a high degree, and yet maintaining in the direction of the bolt's axis, the desirable features of continuity and rigidity, thus avoiding the liability of unequal tension of adjacent bolts. This is undeniably a departure in the right direction, and one that will receive prompt attention in railway mechanical engineering.

3 One other important feature to be considered, however, in adopting a new form or in selecting a new material for staybolts, is ability to resist corrosion under the conditions of use, a feature even more important with staybolts of the proposed high tensile strength and small diameter, than with staybolts of ordinary diameter. For example, the paper gives the actual breaking strength of a 1-in. iron bolt as 32,500 lb., and of a $\frac{7}{16}$-in. spring-steel stembolt as 32,000 lb. If it is assumed that each is reduced $\frac{1}{8}$ in. in diameter by corrosion, this will reduce the breaking-strength of the 1-in. bolt by 23.56 per cent, and of the $\frac{7}{16}$-in. bolt by 48.98 per cent. The breaking-strength of the iron bolt is then 24,843 lb. and that of the spring-steel stembolt is 16,327 lb. Another $\frac{1}{8}$-in. reduction in diameter would bring the strength of the iron bolt to 18,278 lb., and of the spring-steel stembolt to 5878 lb.

4 Formula 4 of Mr. Wille's paper shows that the flexural stress, the ordinary cause of failure, decreases directly as the diameter, yet it is evident that if the bolts are affected by corrosion and in equal amount, this will eventually reduce the tensile strength of the small bolt to a point below the proper factor of safety, while the larger bolt has still tensile strength to spare.

5 Since the new type of staybolt makes it possible to employ

various steels and alloys which cannot be used in the ordinary staybolt, it fortunately provides for a wide range of selection, and quite probably a steel-alloy or mixture may be provided that will resist corrosion equally well or better than the iron ordinarily used.

6 The impurities in the water used also very greatly affect corrosive action, and it is probable that with the new type of bolt it would be advantageous to examine carefully the water of the locality where it is to be used and to select a metal with reference to the character of the water. Information regarding the resistance of various steel alloys to corrosion, in water of ordinary purity, and experiments determining the metal that will give the least corrosion in water having various impurities, are highly desirable, since the new bolt makes possible the use of that metal which combines in the greatest degree flexibility, high elastic limit and resistance to corrosion.

7 A combination of these three qualities, in a staybolt of the type described, will be an innovation much to be desired in locomotive practice.

F. J. Cole. In reading this paper the following occurred to me:

a Have any of these staybolts been applied to locomotive boilers?

b What is their comparative cost?

c With 1-in. ends is there any danger of overstraining the $\frac{3}{8}$-in. diam. spring-steel center in screwing the bolt to place? It would seem that the torsional stress on the comparatively small central part in screwing the bolts to place when they fit tightly in the sheets would be excessive.

d In upsetting the soft ends, does the $\frac{3}{8}$-in. diam. center afford sufficient resistance to avoid injury to the threads from hammering? It is customary in upsetting the ends to use a hammer or heavy weight at the other end of the bolt to afford the necessary resistance and to prevent injury to the threads.

e In Par. 7 Mr. Wille speaks of 12,000 lb. fiber stress being good practice. I presume he has in mind the combined stress due to tension and bending. Current locomotive practice is represented fairly well by 5500 to 6000 lb. for tension alone.

The Author. Mr. Hall has fully described the general characteristics of a staybolt broken in service. The able experiments of Boushinger and Wohler have shown that a detail fracture occurs in parts which have been stressed by flexure above the elastic limit. If the parts be threaded the stress may be localized at the base of the thread which will increase the possibility of failure of parts stressed at or near the elastic limit, but if the parts be not stressed above the "fatigue" elastic limit of the material, it will not fail irrespective of whether it be threaded or of plain section.

2 The bolt described is made of two kinds of material:

a The stem of high-carbon tempered steel.
b The two ends of soft steel.

This arrangement permits the use of a material having such a high elastic limit and provides an ample factor of safety and still allows the soft ends to be rivetted over to make a steam-tight joint. The bolt referred to by Mr. Hall does not fulfil these conditions, as if it were made of steel having a sufficiently high elastic limit it would be impossible properly to rivet the ends.

3 The ends of the composite bolts are not larger than a normal bolt, those in service being made 1 in. in diameter when used in new boilers and $\frac{15}{16}$ in. and $1\frac{1}{16}$ in. when used to replace $\frac{7}{8}$-in. and 1-in. bolts respectively in old boilers. The stems are not made a tight fit into the ends but are threaded so that they can be tightly screwed into the ends by hand thus affording some flexibility in the joint. It is not necessary however to thread the stems as they can be upset and the ends closed around them, making a ball joint, thus having all the advantages with none of the disadvantages of the usual type of flexible bolt.

4 The bolts have been in service for two years in a district notorious for the trouble experienced with corrosion and the bolts are still intact. Mr. Lovell suggests the possibility of providing special steels to resist corrosion. The high-carbon tempered steel being dense and hard is an admirable material to resist corrosion; furthermore as the stems are oil-tempered they have a coat of enamel which prevented the slightest amount of pitting even after two years' service.

5 There are a large number of these bolts in service in locomotive boilers and no difficulty has been experienced either from twisting of the stem in screwing into the boiler or from injury to threads in rivetting.

6 The cost of material entering into the construction of the spring

flexible bolt is very much less than that of the usual type of staybolt since the weight is much less and the materials are the relatively cheap commercial grades of steel instead of the high-priced irons usually employed in the manufacture of staybolts. The labor cost to manufacture is however somewhat higher.

MISCELLANEOUS DISCUSSION

AUTOMATIC FEEDERS FOR HANDLING MATERIAL IN BULK

By C. Kemble Baldwin, Published in The Journal for May

ABSTRACT OF PAPER

This paper is presented with the object of enabling an engineer to choose from eleven types of feeders in use to-day, the one best fitted to his use, line drawings being used so they may be readily compared. When feeding a conveyor, crusher or machine from a storage bin, it is advisable to use some type of automatic feeder. This should be geared to the machine it feeds so that they will start and stop simultaneously. The author favors the shaking feeder because of its simplicity and flexibility.

DISCUSSION

T. A. Bennett. An automatic feeder is absolutely necessary in some installations; in others it is demanded for economic reasons. For example, run-of-mine coal, on account of constriction in the chute, requires properly a 36-in. belt, although it can be handled on a 30-in. belt. With an automatic feeder it is possible to use a 24-in. conveyor provided the capacity will permit. In handling damp sand, a large chute opening is necessary and this usually requires at least a 16-in. conveyor belt. With a feeder, however, this width can easily be reduced to 12 in. A 12-in. conveyor has capacity to take care of nearly every problem in handling damp sand.

2 The feeder is also economical in filling in the blank spaces on the belt. The loading is usually intermittent, the belt being either over-loaded or under-loaded intermittently; the feeder can be regulated to give a uniform maximum loading, greatly increasing the capacity. Intermittent loading also increases the wear on the belt. As the only wear worth considering is that done by the material

coming in contact with the surface of the belt in the delivery of material to it, the larger the load the less is the proportionate wear on the belt.

3 A type of feeder has been developed similar to that in Fig. 8, but doubled; that is, a hopper and either one or two swinging plates at each end and pushing to an outlet at the center part of the skirt boards. This type is now working very satisfactorily in two big plants, the Hudson Company's power house at Jersey City, N. J., and the Illinois Steel Company at Joliet, Ill. The chief advantage over any other is the saving of headroom. Where there is sufficient headroom, the shaker feeder is correct practice and is in general use.

THE AUTHOR. Mr. Bennett's discussion emphasizes three important points with reference to the use of automatic feeders in connection with belt conveyors:

a The installation of the feeder frequently permits the use of narrower belts.

b Delivery of an even and continuous stream of material enables the conveyor to operate at its maximum capacity.

c By loading the conveyor to its full capacity, a smaller proportion of the load comes in contact with the belt, thereby reducing the wear per ton carried on the belt at the loading point.

2 The type of feeder mentioned by Mr. Bennett as similar to that illustrated in Fig. 8 is a variation of that type, used where material is taken from two hoppers; instead of two swinging plates placed side by side, there is a single plate under each hopper. These two plates are connected by rods, so that when one plate is in the forward stroke the other will be in the back stroke. It is therefore nothing more than two single-plate feeders so connected that they operate together.

3 Mr. Bennett is mistaken regarding this type saving headroom over any other type. It requires about the same headroom as the plunger feeder (Fig. 9) and the reciprocating plate feeder (Fig. 10). The great drawback of the swinigng-plate feeder is that it is not self-cleaning, so that if exposed in winter the material will freeze to the bottom plate.

4 This type of feeder was originated by Mr. Lincoln Moss of New York, and the two installations mentioned by Mr. Bennett were designed by Mr. Moss under the writer's direction.

SPECIFIC VOLUME OF SATURATED STEAM

By Prof. C. H. Peabody,[1] Published in The Journal for May

ABSTRACT OF PAPER

The information now extant concerning the properties of saturated steam together with recent experiments presenting results of satisfactory precision, are recapitulated in this paper, and a computation of the specific volumes at various temperatures is made by the aid of the accepted thermodynamic equation and compared with experimental determinations of the same property. The greatest discrepancy between the computed and the experimental values for the specific volumes is shown to be 1/500. Since the essential properties of saturated steam enter into this discussion, the tables of the properties of steam computed from the data now available may be regarded as accurate.

DISCUSSION

Prof. William D. Ennis. The reason for the extrapolation of Fig. 3 is not quite clear to me. The ordinates of this diagram are differences between the Holborn and Henning values for the pressure of saturated steam, and those given by the Peabody formula, $\log p = a - b\,\alpha^{t-100} + c\,\beta^{t-100}$. The diagram is extended to include temperatures above 205 deg., the Holborn and Henning limit. Why would it not be just as satisfactory, if the Holborn and Henning values are satisfactory, to extrapolate directly the curve expressing their results?

2 There seems to be little room for uncertainty in any of the properties of saturated steam, excepting, possibly, the heat of the liquid. The maximum divergence in values for the former, comparing the Dieterici and the modified Regnault values adopted by Professor Peabody, occurs at the highest temperatures: at 220 deg. (an extrapolated point) it is 1.31 cal. or 0.584 per cent. Now if Dieterici does not claim an accuracy exceeding 0.5 per cent at this temperature, and since Professor Peabody admits a possible fractional percentage of error, the true value may be within the limit of estimated error in both computations. The result of taking Dieterici's values would be to make the computed specific volume 0.01 per cent less at 100 deg.,

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[1] Prof. C. H. Peabody, Mass. Inst. of Tech. Dept. of Naval Architecture, Boston Mass.

0.02 per cent less at 140 deg. and 0.045 per cent less at 165 deg., than those tabulated on page 604. The deviation from the Knoblauch, Linde and Klebe results would be thus generally decreased. There is still a possibility that the Dieterici values may be more nearly correct. If the preponderance of error in values of the other quantities entering into the volume formula were in such a direction as to make the computed volumes too small, the lower heats of the liquid used by Professor Peabody might lead to an apparently better result because of a balancing of opposite errors. It does not seem safe to say definitely that such may not be the fact. The uncertainty in the heat of the liquid at 200 deg. is 0.36 per cent rather than 0.25 per cent. The same uncertainty applies to the entropy of the liquid, and a possible error of about 0.16 per cent to the entropy of vaporization. The entropy of saturation at this temperature may then be wrong to as great an extent as 0.23 per cent, or $\frac{1}{25}$. This would introduce a barely noticeable error into computations involving vapor cycles.

3 It is questionable whether permanence, in a matter of this kind, is as desirable as a standard, a flexible standard. Would it not be within the scope of the Society to coöperate with national engineering organizations abroad in the preparation of an international steam table for saturation and superheat, embodying the generally accepted values and subject to modification whenever an undisputed conclusion is reached on the one or two remaining doubtful quantities?

The Author. In reply to Professor Ennis I will first explain that Holborn and Henning give a table of pressure for each degree of temperature, and make no use of an equation except as a means of fairing their results, for which purpose they chose Thiesen's equation which gives divergent values for higher temperatures. Now it happens that the equation which I chose gives value which converge toward Holborn and Henning's values so that it is possible to draw an extrapolation diagram as shown in my paper.

2 Secondly, I wish to say that Dr. Henning has kindly sent me in advance of publication an abstract of results which he has recently obtained for the heat of vaporization of water from 100 deg. to 180 deg. cent. His memoir will soon be available and will show that the results which I have deduced from Dr. Davis' values of the total heat, show a close concordance with these new experimental values. It is not unlikely that we may have a conclusive determination of the remaining quantity, heat of the liquid, but as stated in my paper the concordance of all quantities involved in the computation of steam

tables is even now very satisfactory so that there is no reason to anticipate any necessity for changing tables for engineers.

A NEW TRANSMISSION DYNAMOMETER

By Prof. Wm. H. Kenerson, Published in The Journal for May

ABSTRACT OF PAPER

The transmission dynamometer described in this paper was designed to meet the necessities of a problem requiring a dynamometer in the form of a shaft coupling. The construction of the instrument is shown, together with a number of its applications.

A stationary member provided with an oil-containing chamber, one side of which is a copper diaphragm, as in the Emery testing-machine, is placed between thrust bearings which are urged together by a force proportional to the torque in the shaft produced by a simple system of levers. A gage or other means of measuring the oil pressure in the chamber indicates the torque.

For use where the rate of rotation of the shaft is variable, a combination of gage and tachometer is shown, which will indicate horsepower, speed and torque.

The author mentions the following characteristics: *a* The instrument is compact. One shown in connection with a 3-in. shaft is about 13 in. in diameter and weighs about 160 lb.; *b* it is as rigid as an ordinary flange coupling; *c* it may be made in the form of a coupling, or of a quill on which a pulley is mounted; *d* it will indicate for either direction of rotation of the shaft; *e* the torque may be read or recorded or the work integrated at a considerable distance from the coupling; *f* no corrections are necessary for different rates of rotation; *g* it may be made very sensitive and accurate; *h* the amount of power absorbed is negligible; *i* the instrument is not easily deranged and is unaffected by temperature changes; *j* with suitable material and workmanship there is little likelihood of failure of any part of the instrument. In no case can it fail to drive the shaft or pulley to which it is attached.

DISCUSSION

A. F. Masury. I want to say a few words as to how the Kenerson dynamometer may be applied to the betterment of design in motor vehicles. In the first place, we must have exact data regarding the effect of road irregularities, wind pressures, and the resistances set up by grades and speed. These figures are absolutely necessary in order to determine the best torque to apply on motor gearing and equipment, such as tires, etc., to overcome the existing conditions in each particular car.

2 At present we have two recourses: first, the figures procured by Mr. S. F. Edge at the Brooklands track in England with his Napier car. He first calibrated his motor and then made the test on the track. These figures must necessarily include many errors. Second, the dynamometer at the Automobile Club of America in New York. Here again satisfaction is not entirely procurable as all the road conditions are obtained artificially by attachments on the machine.

3 With the Kenerson dynamometer we can certainly get exact readings while the machine is working on the road. These can even be made graphic if desired. Manufacturers will thus have available means of getting information which should result in more perfect design.

4 There is one thing more, the dynamometer of the Automobile Club of America cost, I believe, in the vicinity of $15,000 by the time it was completely installed, while the price of the Kenerson machine, around $500, will make it possible for even a small manufacturer to get his own reading.

A UNIQUE BELT CONVEYOR

By Ellis C. Soper, Published in The Journal for May

ABSTRACT OF PAPER

This paper contains a description of the installation and operation of a belt conveyor, one-quarter mile long, built on practical lines, requiring less power to operate loaded than empty because the material is conveyed downhill. It is in actual operation at the present time, the only requisite labor being that of a boy to do the oiling and adjust the rolls, etc., which may get out of alignment.

DISCUSSION

T. A. Bennett. Mr. Soper's paper, while giving a practical description of a certain installation, hardly seems to warrant the word "unique." There are many conveyors in regular practice just as long—conveyors which run downhill—in fact, conveyors that need a brake. As for size, there is a 36-in. movable belt conveyor in New York over a thousand feet long, used for filling in the refuse from the city on Riker's Island. The driving arrangement mentioned, from the receiving end of the conveyor, is also common practice.

2 Regarding the maximum length of conveyors, with a flat belt, as in this instance, the limit would be merely the cost of installation as practically any tensile strength desired can be obtained by increasing the number of plies of the belt. With a troughed belt the limit of length would be the tensile strength of the thickest belt that would conform to the trough of the idlers. This limit approaches somewhat the limits the author mentions, although such belts have been put in, as above, for lengths of a thousand feet or more.

3 His take-up has been in use for over five years in belt-conveyor practice. There is one installation at Bilbao, Spain, handling iron ore, which runs down an incline of 13 deg. and needs a brake, and has a counterweighted take-up working in a vertical plane. The take-up and drive are located on the return belt near the foot of the incline.

4 The tonnage of the conveyor is so small that the cost of maintenance per ton is also misleading. The wear of a belt is occasioned by the material coming in contact with it when delivered to it. A narrow stream of material permits each particle to come in contact with a small proportion of the total width, whereas a wide stream utilizes the full width of the belt and furthermore carries a large part of the material on top of the belt without ever touching it. I believe the capacity of this conveyor is something like 20 tons per hour, whereas such a conveyor should easily handle 200 tons per hour. Therefore the average cost for maintenance of the belt per ton carried is high.

Harrington Emerson. The last words in this paper are "The belt should last several years." In the last line of Table 4, it is stated that interest, depreciation and renewals amount to 10 per cent on an investment of $9200. Now, if the belt is to last only a few years, 10 per cent is not sufficient to cover interest, depreciation and renewal. Assuming that the belt lasts four years, the depreciation account alone would be $2300. That would increase the cost per ton from $0.02 to about $0.035.

Fred J. Miller. It might be well to consider that there are other things that constitute part of this plant as well as the belt. As I understand, it is stated that the belt may last only a few years, but the rest of the plant may last enough longer than ten years to make 10 per cent a fair total charge for depreciation.

The Author.[1] The belt conveyor in question has now been in operation about eighteen months, in which time less than $3.00 in repairs has been expended. The belt itself shows little wear and should last ten years. Of course the driving and carrying mechanisms will last indefinitely under ordinary conditions, as there is little wearing of the working parts, due to the slow speed of the belt.

2 The installation, as stated previously, though ample for a capacity of 200 tons per hour, is required to carry not over 20 tons per hour, and certainly the cost per ton for maintenance and other charges is out of proportion to what it would be were the belt carrying anything like full load.

3 The motor at the receiving end of the upper belt has been taken out and the belt has been driven for several months by the "lower" 10-h.p. motor, the "upper" belt being driven by the "quarter-twist" chain mentioned in the paper. To our knowledge, this is the *longest single-driven* belt conveyor (about 2150 ft.) in operation.

[1] Abstracted.

COMMENT ON CURRENT BOOKS

PRACTICAL ALTERNATING CURRENTS AND ALTERNATING-CURRENT TESTING. Charles F. Smith. *Scientific Publishing Company, Manchester, England.* Third edition, revised and enlarged, cloth, 6 by 9; XXI + 455 p.; 236 illustrations. Price 6s.

In this volume the author has endeavored to combine a text-book and a reference book for laboratory work. The experiments are described in detail so that the conclusions derived from them may be followed by anyone not having the means for performing the experiments. The use of higher mathematics has been avoided as far as possible.

Contents by chapter headings: Alternating Electromotive Force and Current; Impedance; Power and Power-Factor; Virtual Value of an Alternating Current; Effect of Capacity; The Transformer; Alternators; Synchronous Motors; The Polyphase Circuit; The Rotary Converter; The Polyphase Induction Motor; Single-Phase Motors; The Composition of Waves.

SIMPLIFIED METHODS OF CALCULATING REINFORCED CONCRETE BEAMS. By W. Noble Twelvetrees. *The Macmillan Company, New York*, 1909. Paper, 5 by 7; 20 p.; 10 illustrations. Price 20 cents.

The author has assembled a number of formulæ from different authorities on reinforced-concrete beams, and has re-stated each formula in terms of a uniform set of symbols. He also presents what are termed "labor-saving" diagrams and describes a calculating instrument for use in reinforced-concrete design.

BRENNAN'S HANDBOOK, A Compendium of Useful Legal Information for Business Men. By B. A. Brennan *John Wiley & Sons, New York*, 1908. Leather, 4½ by 7; 571 p. Price $5.

The author's position as contract manager of the Westinghouse Machine Company, of Pittsburg, Pa., has made necessary a knowledge of the laws on contracts and other instruments for recording, buying and selling transactions. The book is not presented as a final authority on the matters treated but rather as a source of information to enable business men to become familiar with the fundamental principles of business law. A valuable feature is a synopsis of the statutes bearing on the collection laws of the different States. A number of useful legal forms are also given.

Contents by chapter headings: Contracts in general; Sales Contracts; Property—Deeds—Mortgages—Liens—Insurance; Acknowledgments—Power of Attorney—Licenses—Guarantee, Etc.; Notes— Checks—Interest; The Negotiable Instruments Law; Synopsis of Statutes on Conditional Sales—Chattel Mortgages—Mechanics' Liens—Bills and Notes—Forms of Acknowledgments; Collection Laws Tabulated; Legal Forms.

GAS ENGINE THEORY AND DESIGN. By A. C. Mehrtens, M.E. *John Wiley & Sons, New York*, 1909. Cloth, 5½ by 8; V + 256 p.; numerous tables and illustrations. Price $2.50.

To make this book of interest to students, draftsmen, engineers, and men operating engines, the treatment has been somewhat elementary. Following out this idea, also, considerable space—nearly one-half the book—is devoted to design of parts. Complete working drawings are given for a 2½-h.p. marine engine and a ½-h.p. horizontal engine.

Contents by chapter headings: General Principles of Operation; Historical; Applications of the Gas Engine; Heat—Thermodynamics; Combustion; Fuels; Laws of Gases; Gas Engine Efficiency; Explosive Mixtures; Mixing Valves and Carbureters; Governing; Ignition; Cooling; Exhaust; Selection of Type; Determination of the Principal Dimensions; Forces Acting in the Gas Engine; Design and Dimensions of Parts; Gas Engine Manipulation; Testing; Designs.

APPLIED MECHANICS FOR ENGINEERS. By E. L. Hancock. *The Macmillan Company, New York*, 1909. Cloth 5 by 7½; XI + 385 p., 205 illustrations, Price $2.

The author, who is assistant professor of applied mechanics at Purdue University, has sought to make the book different from others on the subject by giving examples to show the application of theory to practical problems. While it is primarily a text-book, the method of presentation in the chapters on moment of inertia, center of gravity, work and energy, friction and impact, make it of value to the engineer. Convenient tables of logarithms, trigonometric functions, etc., are given at the end of the book.

Contents by chapter headings: Definitions; Concurrent Forces; Parallel Forces; Center of Gravity; Couples; Non-Concurrent Forces; Moment of Inertia; Flexible Cords; Rectilinear Motion; Curvilinear Motion; Rotary Motion; Dynamics of Machinery; Work and Energy; Friction; Impact.

BRICKLAYING SYSTEM. By Frank B. Gilbreth, Mem.Am.Soc.M.E. *Myron C. Clark Publishing Co., New York.* Cloth, 6 by 9; XI + 321 p., 167 illustrations, 73 charts. Price $3.

The author has endeavored to put in writing that knowledge which has been handed down by word of mouth from journeyman to apprentice for generations. The various operations in the laying of brick are described and illustrated in great detail. He has also given the rules followed in developing and handling his men, in handling material and in methods of construction. The addition of data on costs and cost systems would doubtless increase the value of the book.

Contents by chapter headings: Training Apprentices; Methods of Management; Methods of Construction; Routing of Material; Scaffolds; The Gilbreth Scaffold-Hod Type; The Gilbreth Scaffold-Packet Type; The Gilbreth Packet System; Method of Building Tall Chimneys; Mortar; Bricks; Bricklayers' Tools, etc.; Lines, Plumbs and Poles; Motion Study; Methods of Laying Brick under Special Conditions; Finishing, Jointing and Pointing; Arches and Chimney Breasts; Tearing Down, Cutting out and Patching Brickwork; Bond.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up of members of the Society. and these are on file, with the names of other good men not members of the Society who are capable of filling responsible positions. Information will be sent upon application.

MEN AVAILABLE

300 Mechanical and electrical engineer desires position (east preferred) as assistant to mill engineer or manager of works on the design and equipment of power plants and industrial works. Age 43. Has had six years' experience as engineer of works with two important manufacturing companies.

301 Construction engineer, eleven years' experience in design and erection of every kind of building, construction, installation of machinery and equipment, desires permanent position with manufacturing concern doing their own work in enlarging and improving their factories, to take entire charge. Best references.

302 Member, broad experience in constructing, erecting and operating.

303 Associate member, graduate mechanical engineer with ten years experience in industrial and architectural engineering, now open to engagement designed and constructed several large power and industrial plants.

304 Junior member, Stevens graduate, desires to make a change. Nine years practical experience in machine-tool, steam and electric machinery; power plants. Good systematizer and familiar with up-to-date shop practice and management New York district preferred.

305 Associate member, consulting mechanical engineer, having completed recent investigation and report leading to important economy of fuel in large factory plant, is now open for a similar engagement. Eight years of practice in reducing power and heating costs in factories.

306 Graduate mechanical engineer, Junior member, desires position with automobile concern which will yield experience in all branches of the business and afford opportunity for advancement. Experienced especially in automobile and electrical engineering; can demonstrate and sell, design and superintend construction.

307 Manual training and University technical graduate; age 33; thirteen years practical experience in machine shop, drafting, designing, testing, estimat-

ing, etc.; has employed and had charge of men; desires position of some responsibility (preferably in Philadelphia, or vicinity); would consider opportunity in the commercial line of engineering or manufacturing.

308 Mechanical engineer with shop experience as molder, pattern-maker, machinist and draftsman; has been engaged on new design and revision of existing designs for more economical production, also devising shop methods and tools and as superintendent of manufacturing plant turning out a line of medium-weight machinery, desires position in which such experience would be of value.

309 Position as superintendent, assistant superintendent, or general foreman. Age 37. Fifteen years office and shop experience in smith and machine shop. as chief draftsman, salesman and superintendent. Good references. Moderate salary acceptable.

310 Junior member, technical graduate of four years standing, American; married; experience in Spanish-speaking country; speaks Spanish, German, Russian and some French; wishes employment with firm having European or Latin-American connections.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS.

ARMSTEAD, F. C. (1906), care of Westinghouse Mch. Co., Attica, N. Y.

BAKER, Dickerson G. (1905), Wks. Mgr., Blake & Knowles Steam Pump Wks., East Cambridge, and *for mail*, 11 Mt. Pleasant St., Winchester, Mass.

BAUSCH, F. E. (1904), Mgr., Hooven, Owens, Rentschler Co., 1316 Chemical Bldg., St. Louis, Mo.

BERG, Hart O. (1898; 1903), Engr., 72 Victoria St., Westminster, S. W., London, England, and 32, Ave. Champs Elysées, Paris, France.

BEVERLEY, Richard Carter (Junior, 1906), Partner, W. P. Longworth & Co., Engrs. and Contrs., and *for mail*, 611 E. Franklin St., Richmond, Va.

BILLINGS, A. W. K. (1909), care J. G. White & Co., Inc., 43 Exchange Pl., New York, N. Y.

BRAUN, Carl F. (Junior, 1907), Mgr., Standard Engrg. Co., 503 Market St., San Francisco, Cal.

BRECKENRIDGE, L. P. (1890), V. P., 1907–1909; Prof. Mech. Engrg. Sheffield Scientific Sch., New Haven, Conn.

BRESLOVE, Joseph (Junior, 1906), Westinghouse Mch. Co., East Pittsburg, and *for mail*, cor. Emerson and Alder Sts., E.E., Pittsburg, Pa.

CHAMBERLAIN, Harry M. (1907), 17 Wrentham St., Dorchester Center, Mass.

COLE, Cyrus L. (Junior, 1908), 619 Walker St., Milwaukee, Wis.

CUMMINGS, Edgar C. (1906), Gooding, Lincoln Co., Idaho.

DAVIS, A. C. (1909), care of Penna. Lines, Wellsville, O.

FITCH, Alfred L. (Associate, 1907), Charge of Spec. Mchy. Design, Western Elec. Co., 259 S. Clinton St., and *for mail*, 1132 E. 45th St., Chicago, Ill.

FOSTER, Charles F. (1890), 416 W. Indiana St., and *for mail*, 317 S. Irving Ave., Chicago, Ill.

FRITZ, A. L. G. (Junior, 1907), Ford, Bacon & Davis, 115 Broadway, New York, and 99 Elmwood St., Woodhaven, L. I., N. Y.

GANTT, Henry L. (1888), Manager, 1908–1911; Cons. Engr., 120 W. 57th St., New York, N. Y.

GILLIES, Wm. F. (Junior, 1905), Box 286, Douglas, Ariz.

GOLDINGHAM, Arthur Hugh (1907), De La Vergne Mch. Co., Foot E. 138th St., and *for mail*, 552 Riverside Drive, New York, N. Y.

HATHAWAY, H. K. (Associate, 1908), V. P., Tabor Mfg. Co., 18th and Hamilton Sts., Philadelphia, Pa.

HAUGHTON, Frank A. (1903), Genl. Supt., Taylor Iron and Steel Co., High Bridge, N. J.

HAZELTON, William S. (1909), 475 Second Ave., Detroit, Mich.

HELVEY, Clarence H. (Junior, 1905), Hamilton Engrg. Co., Hamilton, O.

HENNING, Gustavus C. (1880), Manager, 1896–1899; Life Member, 1890; Cons. Engrg., 150 Nassau St., and *for mail*, 413 Convent Ave., New York, N. Y.

HOLCOMB, A. Elton (Junior, 1901), V. P. and Mgr., Earth Moving Machinery Co., and *for mail*, 4323 W. Van Buren St., Chicago, Ill.

HOLLOWAY, Thurman Welford (Junior, 1906), International Corr. Schools, Ltd., Kingsway, London, W. C., England.

IRELAND, M. L. (Junior, 1902), Coast Artillery Corps, Fort Stevens, Ore.

JOHNSON, Lewis (1880), Pres., Johnson Iron Wks. (Ltd.), P. O. Drawer 241, New Orleans, La.

JOHNSON, Louis L. (1908), Gas Engr. Elec. Dept., Southern Pacific Co., Room 1110, Flood Bldg., San Francisco, Cal.

JOHNSON, Paul F. (1905), Monadnock Bldg., San Francisco, Cal.

JORDAN, Wm. Allen (Junior, 1903), Chas. Warner Co., Wilmington, Del.

MACLAREN, James G. (Associate, 1908), Engr., Lamson Cons. Store Service Co., 225 5th Ave., New York, and *for mail*, P. O. Box 541, Harrison, N. Y.

MILLER, John S. (1900; 1907), Yuba Const. Co., Marysville, Cal.

MINCK, Peter (Junior, 1909), Mech. Engr. with Edwin Burhorn, 71 Wall St., New York, N. Y., and 112 Gardner St., Union Hill, N. J.

PENNOCK, George Alger (Junior, 1903), Asst. Supt., Service and Maintenance, West. Elec. Co., Hawthorne, and *for mail*, 4012 Jackson Blvd., Chicago, Ill.

POMEROY, Harry D. (1892; 1904), Supt. and Mgr., M. C. Ryan Co., Phoenix, N. Y.

SANGUINETTI, Percy A. (1886), Cons. Engr., 335 S. First Ave., Mt. Vernon, N. Y.

SHANTZ, O. S. (1900), care of Shantz Mfg. Co., and *for mail*, 475 Norwood Ave., Buffalo, N. Y.

SHARPE, Henry D. (Associate, 1901), Treas., Brown & Sharpe Mfg. Co., and *for mail*, 130 Angell St., East Side Sta., Providence, R. I.

SHIRLEY, Robert (1906), Wks. Mgr., Chapman Valve Mfg. Co., Indian Orchard, Mass., and *for mail*, 26 Lennox St., Hartford, Conn.

SMITH, Chas. F. (1889), Cons. Elec. and Mech. Engr., 25 City Hall Pl., 10th Floor, New York, and 252 Carlton Ave., Brooklyn, N. Y.

SMITH, Roy B. (Junior, 1905), 2213 Adams Ave., Norwood, Cincinnati, O.

SPONSLER, Charles Fred'k (Junior, 1904), Ch. Engr., Bureau of Standards, Dept. of Commerce and Labor, and *for mail*, 1644 Park Rd., Washington, D. C.

STARKWEATHER, Wm. G. (1897), 53 State St., Boston, and 17 Gibson Rd., Newtonville, Mass.

STRATTON, H. F. (Junior, 1904), Sales Mgr., Elec. Controller & Mfg. Co., and *for mail*, Suite 7, 1523 E. Blvd., Cleveland, O.

SWAIN, George F. (1883), Prof. Civ. Engrg., Graduate Sch. Applied Science, Pierce Hall, Oxford St., Harvard Univ., Cambridge, Mass.

TAGGE, Arthur C. (1901), Ch. Engr., Eastern Canada Portland Cement Co., Dombourg, P. Q., Canada.

TALCOTT, Robt. Barnard (1907), Asst. Ch. Mech. and Elec. Engr., Office of Supervising Arch., Treas. Dept., and *for mail*, 3038 Dunbarton Ave., N. W., Washington, D. C.

TROTZ, J. O. E. (1906) Svanevik, Ronneby, Sweden.

TUCKER, Edwin D. (1898), Mech. Engr., 189 6th Ave., New York, N. Y.

ULBRICHT, T. C. (Junior, 1908), Instr. Engrg. Dept., Pratt Inst., and *for mail*, 170 St. James Pl., Brooklyn, N. Y.

VAN DEINSE, A. F. (Junior, 1905), 123 San Francisco St., El Paso, Tex.

VOSE, Fred Hale (Junior, 1906), Mech. Engrg. Dept., Case Sch. Applied Science and *for mail*, 10521 Lee Ave., N. E., Cleveland, O.

WHEELER, Chas. Van Cise (1906), Supt., Projectile Dept., Firth-Sterling Steel Co., P. O. Box 812, and *for mail*, 1609 16th St., N. W., Washington, D. C.

WHITE, James A. (Junior, 1900), 22 Atlantic St., Lynn, Mass.

WILLIAMS, George W. (1904; 1907), Asst. Engr., Geo. M. Brill, 1134 Marquette Bldg., and *for mail*, 365 E. 59th St. Chicago, Ill.

WINSHIP, W. E. (1909), Cor. 179th St. and Fort Washington Ave., New York, N. Y.

DEATHS

BLAIR, Archibald W.

NEW MEMBERS

BAILEY, H. Morell (Junior, 1909), 523 Somerset St., Johnstown, Pa.

FARWELL, E. S. (1899), 309 Broadway, New York, N. Y.

FLETCHER, E. Leslie (1909), Court Exchange, Bridgeport, Conn.

GIFFORD, Byron T. (Junior, 1909), 407 First Natl. Bank Bldg., Chicago, Ill.

McGLONE, Roy G. (Junior, 1909), Ch. Engr., U. S. Dredge Guadalupe, Victoria, Tex.

SCHEEL, Henry V. R. (Junior, 1909), Brighton Mills, and *for mail*, 205 Van Houten Ave., Passaic, N. J.

STANTON, Francis A. O'C. (Junior, 1909), 1104 Bloomfield St., Hoboken, N. J.

TREFTS, John C. (1909), Farrar & Trefts, 54–56 Perry St., Buffalo, N. Y.

WEGG, David S. (Junior, 1909), Secy. to Head of Telluride Inst., Olmsted, Provo, Utah.

PROMOTIONS

SHIEBLER, Marvin (1905–1909), Stone & Webster Engrg. Corp., Boston, Mass., and *for mail*, 30 Church St., New York, N. Y.

GAS POWER SECTION

CHANGES OF ADDRESS

GOLDINGHAM, Arthur H. (1909), De La Vergne Mch. Co., Foot E. 138th St., and *for mail*, 552 Riverside Drive, New York, N. Y.

McNEIL, Merritt C. (Affiliate, 1909), Janette Ct., Millvale and Ben Venue Ave., Pittsburg, Pa.

SHOOP, R. B. (Affiliate, 1908), 511 De Kalb Ave., De Kalb, Ill.

ULBRICHT, T. C. (1908), Instr. Engrg. Dept., Pratt Inst., and *for mail*, 170 St. James Pl., Brooklyn, N. Y.

VOSE, Fred Hale (1909), Mech. Engrg. Dept., Case Sch. Applied Science, and *for mail*, 10521 Lee Ave., N. E., Cleveland, O.

NEW MEMBERS

BERG, P. Eskil (Affiliate, 1909), Engr. Turbine Dept., Genl. Elec. Co., Schenectady, N. Y.

FINLAY, Lance Geo. (Affiliate, 1909), Mgr., L. G. Finlay & Co., New England Bldg., Cleveland, O.

FISKE, Geo. Wallace (Affiliate, 1909), Mech. Engr., 480 E. 22d St., Oakland, Cal.

LITZ, Earl Ewing (Affiliate, 1909), Genl. Mgr., Combustion Util. Co., 60 Wall St.. New York, N. Y.

STUDENT SECTION

CHANGES OF ADDRESS

CRAIG, Ollison (Student, 1909), 1143 Portland Pl., Boulder, Colo.

DAUGHERTY, R. L. (Student, 1909), 415 Lytton Ave., Palo Alto, Cal.

EIDMANN, Frank L. (Student, 1909), P. O. Box 173, Lansing, Mich.

MUDD, John P. (Student, 1909), 2101 W. Tioga St., Philadelphia, Pa.

COMING MEETINGS

October and November

Secretaries or members of societies whose meetings are of interest to engineers are invited to send in their notices for publication in this department. Such notices should be in the editor's hands by the 18th of the month preceding the meeting.

ALABAMA LIGHT AND TRACTION ASSOCIATION
November 15, 16, annual convention, Birmingham. Secy., Lloyd Lyon, 158 Government St., Mobile.

AMERICAN CHEMICAL SOCIETY, New York Section
October 8, 108 W. 55th St. Paper: Partial Vapor-Pressures of Binary Mixtures. Secy., C. M. Joyce.

AMERICAN CIVIC ASSOCIATION
November 15–19, Cincinnati, O. Secy., Richard B. Watrous, Harrisburg, Pa.

AMERICAN GAS INSTITUTE
October 20–22, Hotel Pontchartrain, Detroit, Mich. Secy., A. B. Beadle, 25 West 39th St., N. Y.

AMERICAN MINING CONGRESS
September 27–October 2, Goldfield, Nev. Papers on Silver Exchange. Secy., J. F. Callbreath, Jr., Denver, Colo.

AMERICAN PUBLIC HEALTH ASSOCIATION
October, Richmond, Va. Secy., C. O. Probst, Columbus, O.

AMERICAN RAILWAY ASSOCIATION
November 17, Chicago, Ill. Secy., W. F. Allen, 24 Park Pl., New York.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION
October 19–21, annual convention, Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine Ry., Concord, N. H.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
October 12, November 9, monthly meetings, 29 W. 39th St., New York; October 16, St. Louis, Mo.; October 20, Boston, Mass. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS
November 9–11, annual meeting, Little Rock, Ark. Secy., A. Prescott Folwell, 239 W. 39th St., New York.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION
October 4–8, annual convention, Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York.

ASSOCIATION OF CAR LIGHTING ENGINEERS
October 5–8, annual convention, Chicago, Ill. Secy., G. B. Colegrove, 6250 Drexel Ave., Chicago, Ill.

CAR FOREMEN'S ASSOCIATION OF CHICAGO
October 11, annual meeting. Secy., Aaron Kline, 326 N. 50th Court.

CENTRAL RAILWAY CLUB

November 12, Hotel Iroquois, Buffalo, N. Y., 8 p.m. Paper: Application of Electricity to the Movement of Freight, G. H. Condict. Secy., H. D. Vought.

CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA

October 19, November 16, Prince George Hotel, Toronto, Ont. Papers: Care and Maintenance of Elevators, J. Shales; Gas Engines, their Origin and Commercial Use, G. M. Henderson. Secy., C. L. Worth, Union Sta.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION

October 7–9, annual convention, Denver, Colo. Papers: The Commercial Field; Meters and Testing; Lamps and Illumination. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

EMPIRE STATE GAS AND ELECTRIC ASSOCIATION

November 17, 18, 29 West 39th St., New York. Secy., C. H. B. Chapin.

MODERN SCIENCE CLUB

October 12, semi-annual meeting; October 19, Paper: Air Compressors, S. B. Redfield; October 26, Paper: Power, F. L. Johnson. Secy., J. A. Donnelly, 125 S. Elliott Pl., Brooklyn, N. Y.

NATIONAL MUNICIPAL LEAGUE

Week of November 15, Cincinnati, O. Secy., C. R. Woodruff, 121 S. Broad St., Philadelphia, Pa.

NEW ENGLAND RAILROAD CLUB

October 12, Copley Square Hotel, Boston. Paper: Railroad Operating Statistics, William J. Cunningham. Secy., Geo. H. Frazier, 10 Oliver St.

NEW YORK RAILROAD CLUB

November 19, annual meeting, 29 W. 39th St. Secy., H. D. Vought, 95 Liberty St.

OHIO SOCIETY MECHANICAL ELECTRICAL & STEAM ENGINEERS

November 19, 20, main annual meeting, Lima, O. Secy David Gaehr, Schofield Bldg., Cleveland.

RAILWAY CLUB OF PITTSBURG

October 22, annual meeting, Monongahela House. Secy., J. D. McIlwain, care P. & L. E. R. R.

RAILWAY SIGNAL ASSOCIATION

October 12–14, Louisville, Ky. Secy., C. C. Rosenberg, 712 North Linden St., Bethlehem, Pa.

RICHMOND RAILROAD CLUB

November 8, annual meeting. Secy., F. O. Robinson.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA

October 5–7, Toronto. Secy., Alcide Chausse, R.S.A., P. O. Box 259, Montreal, Que.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

November 18, 19, 29 W. 39th St., New York. Secy., W. H. Baxter.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB

November 18, annual meeting, Candler Bldg., Atlanta, Ga. Papers on Oil Lamps, Front-End Arrangements, Draft-Rigging. Secy., A. J. Merrill, 218 Prudential Bldg.

TECHNICAL SOCIETY OF BROOKLYN

October 1, annual meeting, Arion Hall, Arion Pl., 8.30 p.m. Pres., M. C. Budell, 20 Nassau St., New York.

TECHNICAL SOCIETY OF WASHINGTON
October 6, annual meeting, 314 C St. N. W. Secy., Paul Bausch.

WESTERN ASSOCIATION OF ELECTRICAL INSPECTORS
October 26-28, annual meeting, Detroit, Mich.

WESTERN SOCIETY OF ENGINEERS
October 6, 20, November 3, 20, 1735 Monadnock Blk., Chicago, Ill. Papers: Wood Preservation; Hydraulic Mining of Auriferous Gravels, J. W. Phillips; Loss of Heat through Furnace Walls, W. T. Ray, Henry Kresinger; The Panama Railroad, Ralph Budd.

MEETINGS TO BE HELD IN ENGINEERING SOCIETIES' BUILDING

Date October	Society	Secretary	Time
1	Explorers' Club	H. C. Walsh	8.30
2	Amer. Soc. Hungarian Engrs. & Archts	Z. deNemeth	8.30
6	Wireless Institute	S. L. Williams	7.30
7	Blue Room Engineering Society	W. D. Sprague	8.00
8	American Institute Electrical Engrs	R. W. Pope	8.00
12	The American Society of Mech. Engrs	C. W. Rice	8.00
14	Illuminating Engineering Society	P. S. Millar	8.00
15	New York Railroad Club	H. D. Vought	8.15
19	New York Telephone Society	T. H. Lawrence	8.00
27	Municipal Engineers of City of New York	C. D. Pollock	8.15
November			
3	Wireless Institute	S. L. Williams	7.30
4	Blue Room Engineering Society	W. D. Sprague	8.00
5	Explorers' Club	H. C. Walsh	8.30
6	Amer. Soc. Hungarian Engrs. and Archts	Z. deNemeth	8.30
9	The American Society of Mech. Engrs	C. W. Rice	8.00
11	Illuminating Engineering Society	P. S. Millar	8.00
12	American Inst. Electrical Engrs	R. W. Pope	8.00
16	New York Telephone Society	T. H. Lawrence	8.00
17–18	Empire State Gas & Elec. Assoc.	C. H. B. Chapin	All day
18–19	Naval Architects and Marine Engrs	W. H. Baxter	All day
19	New York Railroad Club	H. D. Vought	8.15
24	Municipal Engineers of City of New York	C. D. Pollock	8.15

ACCESSIONS TO LIBRARY

BOOKS

Association of Railway Telegraph Superintendents. Proceedings of the Annual Meeting, 1909. *Milwaukee, Wis., 1909.* Gift.

Association of Transportation and Car Accounting Officers. *Proceedings.* Eleventh Meeting, June 1909. *Montreal, Que., 1909.* Gift.

Cambridge (Mass.) Water Board. Annual Report, December 1, 1907–April 1, 1909. *Cambridge, 1909.* Gift.

Castings Directory. 1908. *Cleveland, O., 1908.* Gift of Gardner Printing Co.

Commission on Additional Water Supply for the City of New York. Report of Department of Pumping, November 30, 1903. *New York,* 1904.

Definition el la Mésure Industriellé de L'Acceleration des Trains By C. O. Mailloux. *Paris, 1908.* Gift of author.

Kansas State Agricultural College. Forty-Sixth Annual Catalogue, 1908–1909. *Topeka, Kan., 1909.* Gift.

Metallographie. By Dr. W. Guertler. Vol. 1. *Berlin, Gebruder Borntraeger, 1909* Gift of publishers.

Municipal Engineers of the City of New York. *Proceedings, 1908. Neu York, 1909.* Gitf.

New Orleans Sewerage and Water Board. Eighteenth Semi-Annual Report. *New Orleans, La., 1908.* Gift.

Notes on Explosive Mine Gases and Dusts. By R. T. Chamberlin. (Bulletin No. 383, U. S. Geological Survey.) *Washington, Govt., 1909.* Gift.

Osterreichischen Ingenieur-und Architekten Vereines. XXXVIII Verzeichnis der Mitglieder. *Vienna 1909.* Gift.

Pacific Municipalities. Vol. 21. No. 1. *San Francisco, Cal., 1909.* Gift of the League of California Municipalities.

Pan-American Scientific Congress. Report of Delegates of the United States. *Washington, Govt.,* 1909.

Railway Signal Association. *Gift. Proceedings.* Vol. 3, 1906; Vol. 5, 1908.

Reinforced Concrete Design, Extracts from Concrete, Plain and Reinforced, 2d Ed. By F. W. Taylor and S. E. Thompson. *New York, 1909.* Gift of authors.

Smokeless Combustion of Coal in Boiler Plants. By D. T. Randall and H. W. Weeks. (Bulletin No. 373, U. S. Geological Survey.) *Washington,* Govt., 1909. Gift.

First International Congress of the Refrigerating Industries, Paris, October 5-12, 1908

Gift of Gardner T. Voorhees

Programs in French, German and English.

Summaries in French, German and English of papers and reports presented to the general secretary before August 28, 1908. *Paris, 1908.*

Reports and Papers contained in pamphlet, Fabrication des Gobelets en Glace, by Brevet Huizier; Meat Trades Journal and Cattle Salesman's Gazette, *London, October 1, 1908;* Zeitschrift für die Gesamte Kälte-Industrie, September 1908; La Glace et les Industries du Froid, *April 1907, May 1908;* La Bière et les Boissons Fermentées, *July 15, September 15, 1907;* Ice and Cold Storage, *October 1908;* L'Événément, L'Evénément Illustré, *October 5, 1908;* Société du Froid Industriel, *March 1908;* L'Édilité Technique, *September 1908,* Le Nouvel Abattoir de Soissons

Holzimprägnierung. Val. Allut Noodt. *Paris, 1908.*

Reports on the Refrigerating Industries in Great Britain, *London, 1908;* France, *October, 1908;* Germany, *Munich and Berlin,* 1908; Hungary, *Budapest, 1908;* Italy, *Rome, 1908;* New Zealand, *Wellington, 1908;* Argentine Republic, *Paris,* 1908.

Catalogues

Brünn-Königsfelder Maschinenfabrik. Paraffin-Kühlanlage für die Mineralol Raffienerie "Schodnica" in Dzieditz.

Compagnie des Epurateurs Kennicot. Epuration, filtration et distillation des eaux.

B. Lebrun. Machines du froid et de la Glace, moteurs a gaz pauvre, et pétrole.

B. Lebrun, *Paris.* Ice and refrigeration machinery, refrigerating plant installations.

L. Rousseau et Cie. La construction des installations frigorigues.

Mille & Pourcel, *Paris.* Ice machines, gas and gasolene engines for refrigerating plants, refrigerating machinery.

Société Anonima per Frigorigeni Motori. "Motorfrigors" (Motors).

Sulzer Frfres. La nouvelle installation frigorigue des glacières de l'alimentation à Paris.

EXCHANGES

American Society of Heating and Ventilating Engineers. *Transactions.* Vol. 13. *New York,* 1908.

Engineering of Ordnance. By A. T. Dawson. *London, 1909.* (Supplement to Vol. 19 of Transactions of the Junior Institution of Engineers.)

Incorporated Institute of Automobile Engineers. Report of Proceedings, Session of 1907–1908. Vol. 2. *London,* 1908.

Index to the Reports of the Commissioner of Education. 1867–1907. *Washington, 1909.*

Institution of Civil Engineers. Minutes of Proceedings. Vol. 176. *London, 1909.*

Mining Institute of Scotland. List of Members. 1908–1909. *Hamilton,* 1909.

Yale University. Report of the President, 1909. *New Haven, Conn.,* 1909.

TRADE CATALOGUES

Sims Co., *Erie, Pa.* Steam separator for vertical and horizontal pipe; bulletins of power-plant appliances, as feed-water heaters, sheet-iron exhaust-heads, hot-water generators, steam separators, water softeners, oil separators, etc.; folder, May 22, 1909, purchasers of Sims feed-water heaters and hot-water generators.

Century Electric Co., *St. Louis, Mo.* Single-phase motors.

Joseph T. Ryerson & Son, *Chicago, Ill.* Monthly stock lists of machinery, iron and steel material.

Scully Steel and Iron Co., *Chicago, Ill.* Stock list of bolts, screw punches, blacksmith's vises, etc.

General Electric Co., *Schenectady, N. Y.* Folders on feeder-regulators, fan-motors, measuring instruments, new G. E. Tungsten lamp for economic consumption, Edison gem lamps for standard multiple-lighting circuits, Tungsten lamp installation, various applications. Bulletin No. 4665, Electrical operation of pulp and paper mills; No. 4675, Single-phase motors, type RI; No. 4677, Sprague G. E. type M control system; No. 4680, Sign lighting with G. E. Tungsten lamps; No. 4687, direct-current motor-starting rheostats CR-107 and CR-111; No. 4688, Compound meter board non-inflammable, non-cracking or warping, etc.

National Electric Lamp Association, *New York.* Advantages of Tungsten lamp.

T. Richard, *80 Rue Taitbout, Paris.* Conveying machinery, overhead cranes, and coal-handling machinery.

Underfeed Stoker Co. of America, *Chicago, Ill.* Publicity Magazine, August 1909.

United Electric Light and Power Co., *New York.* Light, August 1909.

Westinghouse Electric and Mfg. Co., *Pittsburg, Pa.* Folders on Type D, Type A automatic mercury-rectifier battery-charging outfit, fans, electric motors, electric power for domestic purposes, reading meters, 8-in. fan motors for alternating and direct current. Circular No. 1079, O. I. W. C. transformers; No. 1144, direct-current mill motors; No. 1163, Type DA small motors; No. 1164, Type MS mill motors polyphase alternating-current circuits.

Whitehall Portland Cement Co., *Philadelphia, Pa.* Cementology, June and July 1909.

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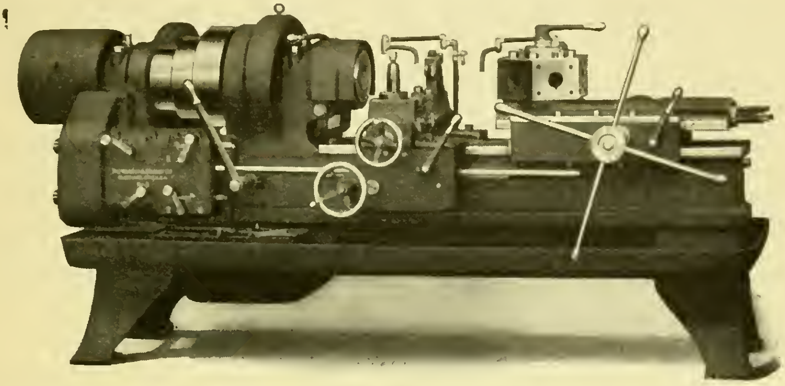

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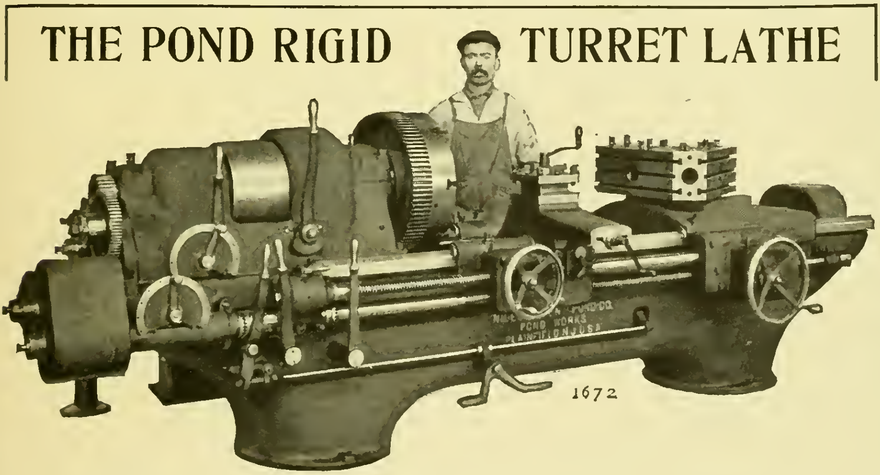

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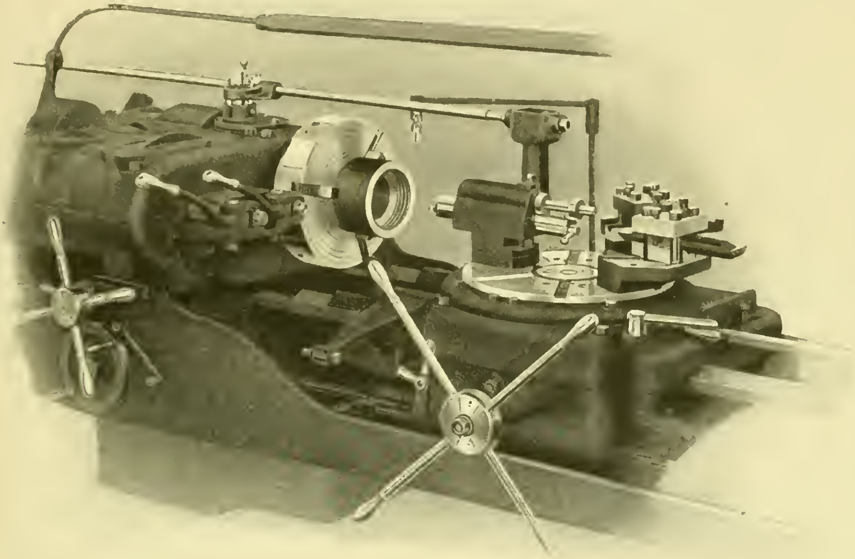

The above cut shows the chasing tool in working operation (some of the other tools have been removed to give a fuller view).

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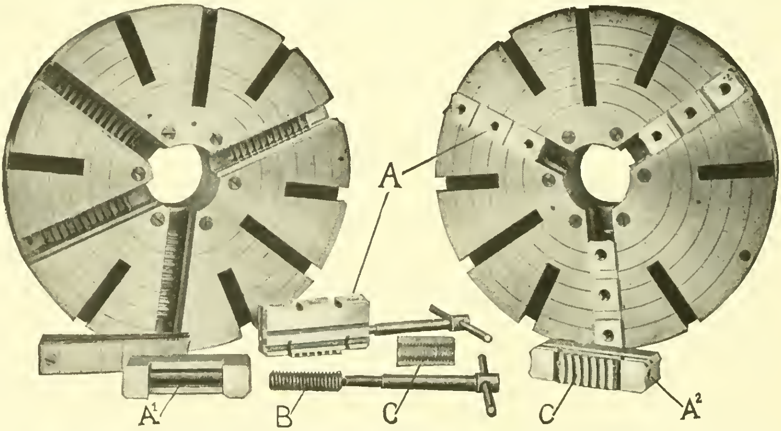

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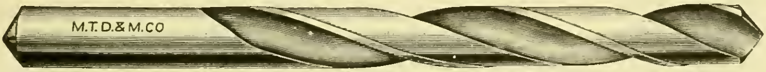

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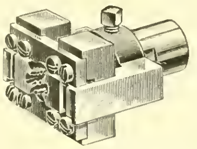
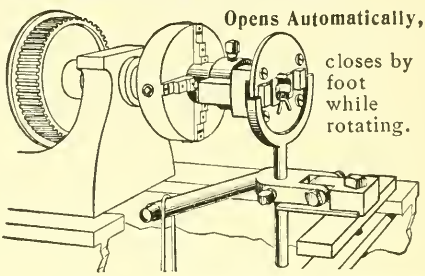

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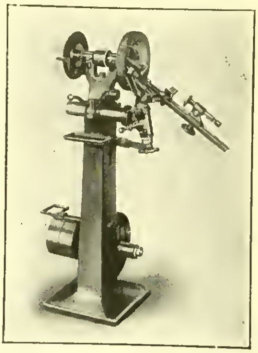

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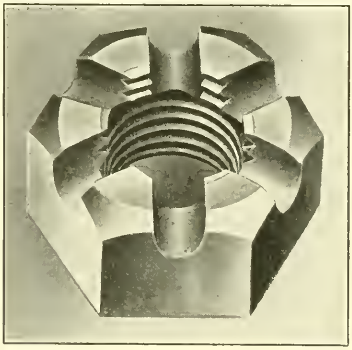

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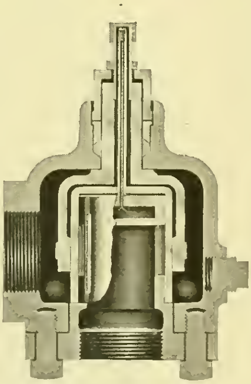

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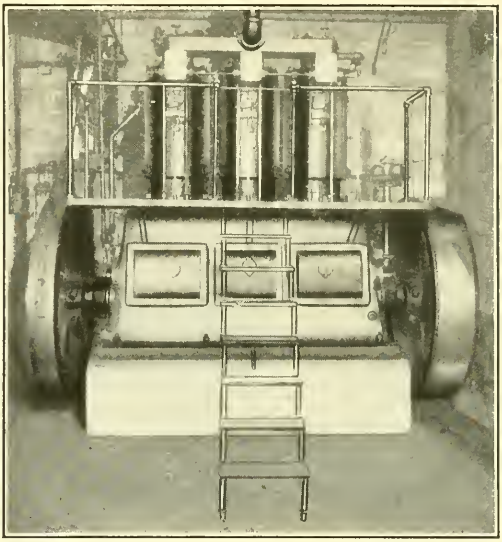

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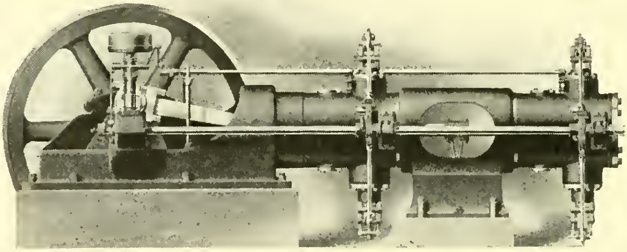

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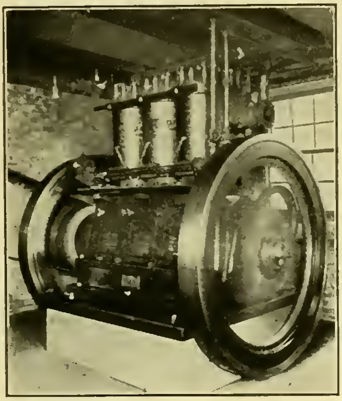

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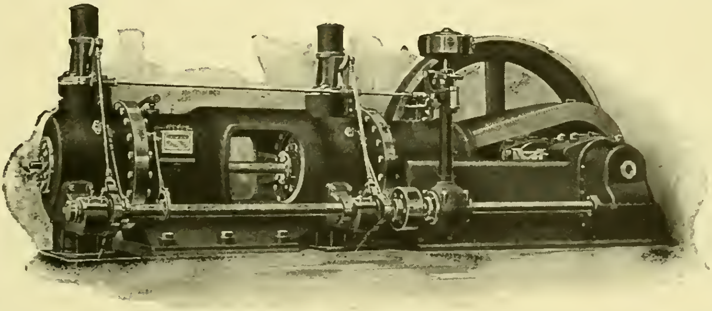

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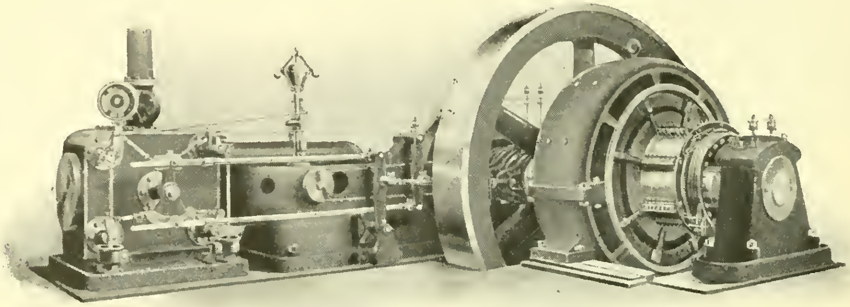

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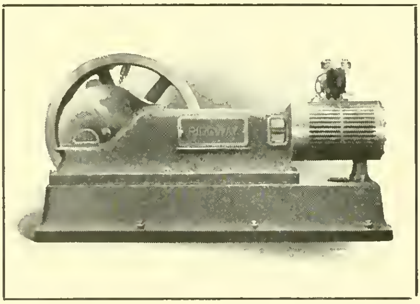

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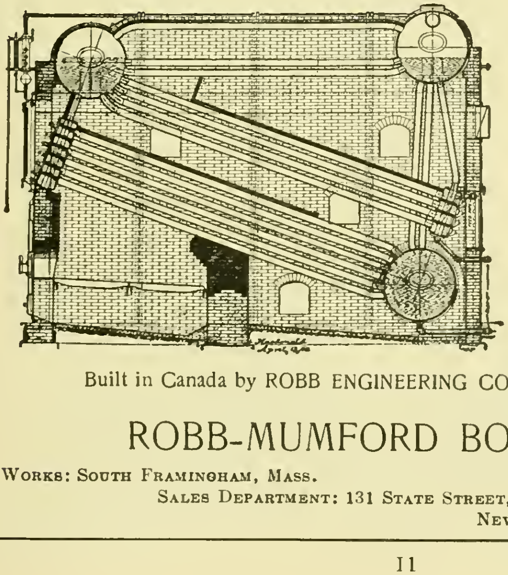

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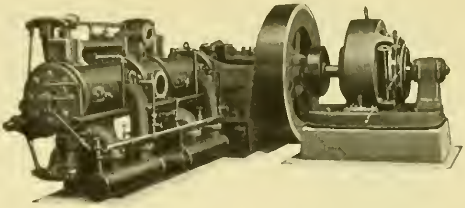

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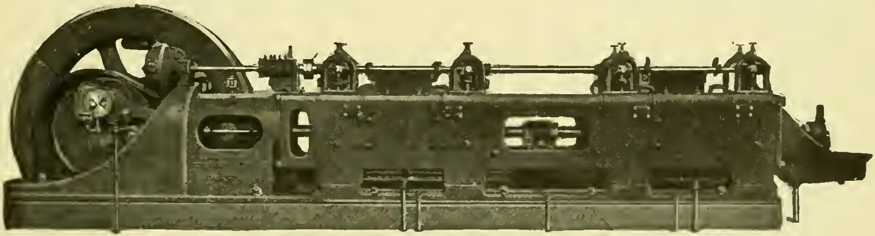

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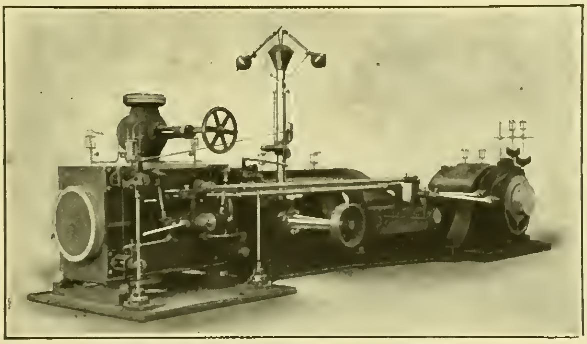

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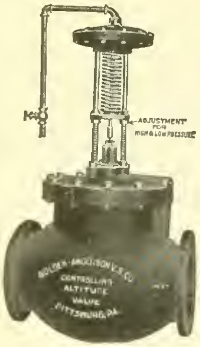
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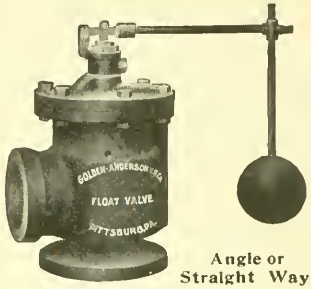

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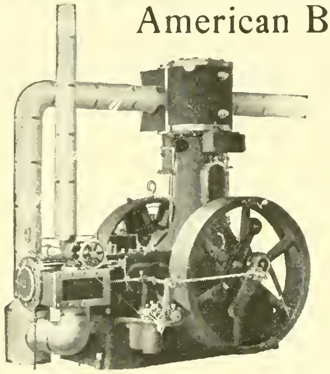

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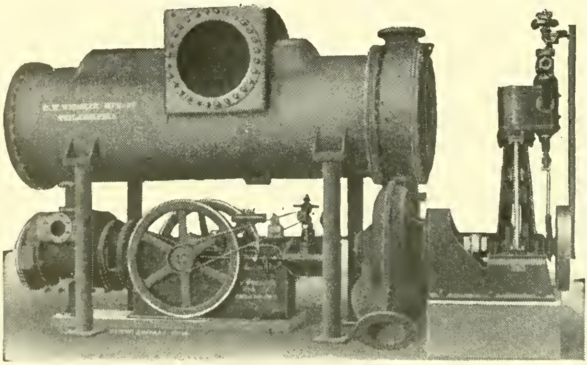

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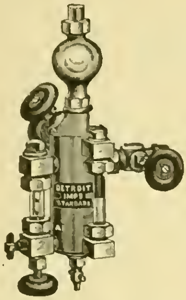

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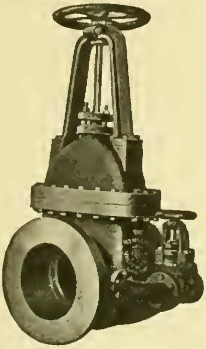

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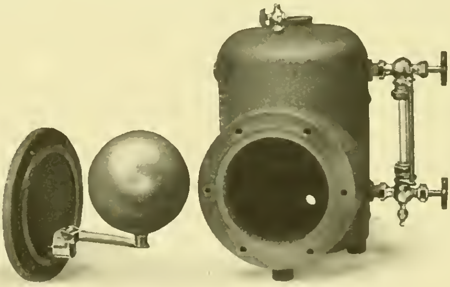

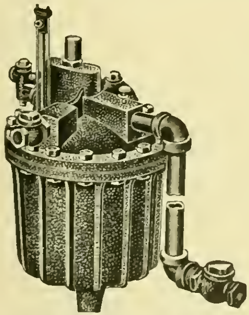

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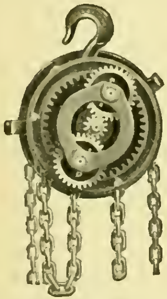

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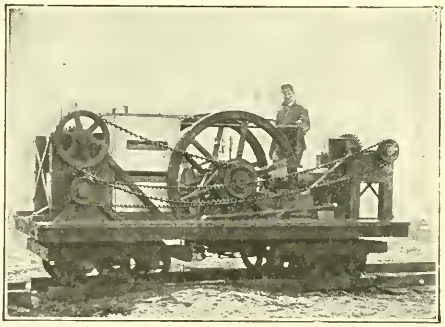

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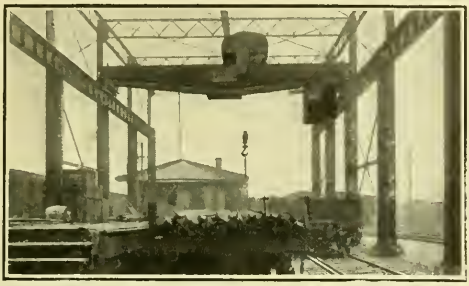

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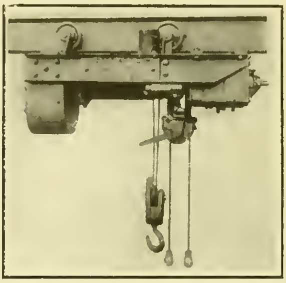

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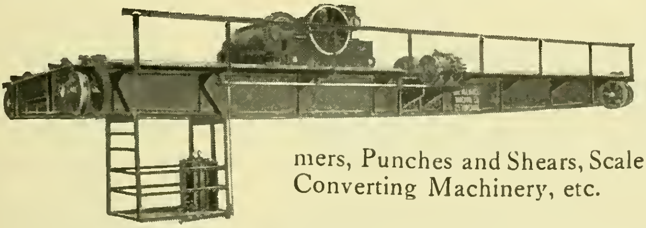

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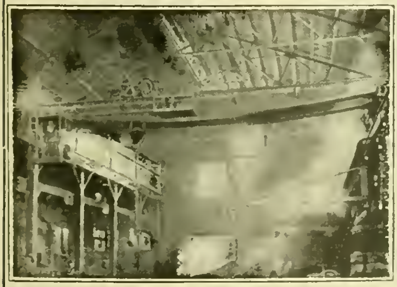

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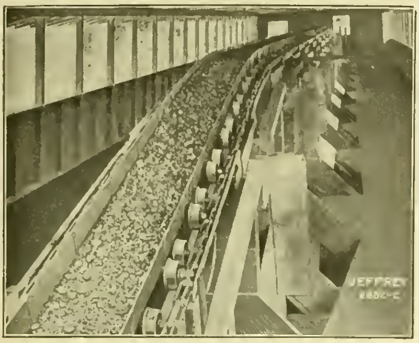

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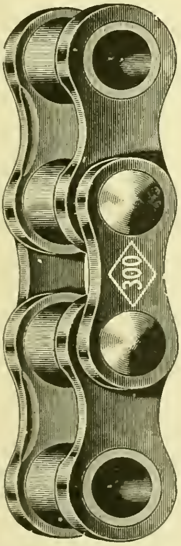

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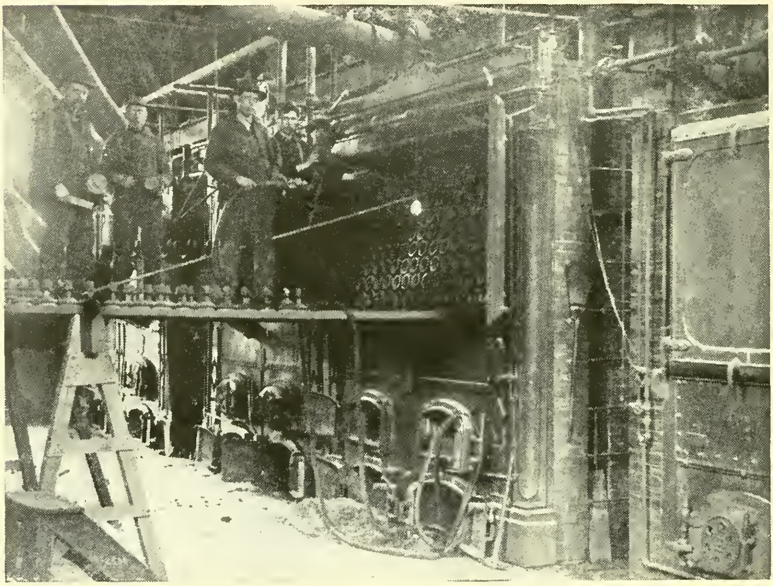

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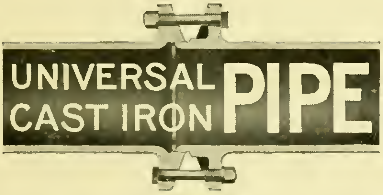

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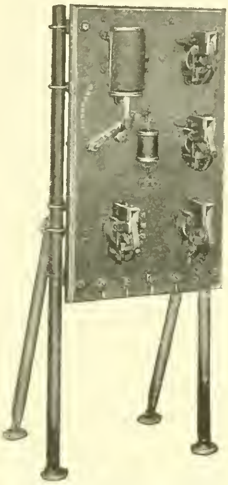

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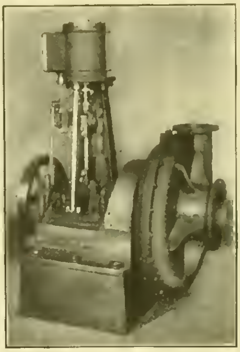

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ALPHABETICAL LIST OF ADVERTISERS

Page
Albany Steam Trap Co. 15, 35
Alliance Machine Co. 19, 43
Almy Water Tube Boiler Co. 32
Alvey-Ferguson Co. 43
American Engine Co. 14, 32
American Pulley Co. 46
American Steam Gauge & Valve Mfg. Co. 35
American Steam Pump Co 40
American Tool & Machine Co. 27
American Watch Tool Co. 27
Arnold Co., The. 26
Ashton Valve Co. 36
Atlantic Hydraulic Machinery Co. . . 40

Bacon, Earle C. 26
Baldwin, Bert. L 26
Ball Engine Co. 32
Barr, H. G. 27
Beggs & Co., Jas. 8, 34
Betts Machine Co. 27
Blaisdell Machinery Co. 31
Blake Co., Geo. F. 40
Booth Co., L. M. 36
Box & Co., Alfred. 19, 43
Bruce-Macbeth Engine Co. 34
Buckeye Engine Co. 8, 32
Builders Iron Foundry 18, 40
Bulkley, Henry W. 36

Caldwell & Son Co., H. W. 43
Carborundum Co. 27
Card Mfg. Co., S. W. 27
Carlyle-Johnson Machine Co. 46
Carpenter Tap & Die Co., J. M. . . 4, 27
Carrier Air Conditioning Co. . . . 23, 48
Central Foundry Co. 23, 48
Chapman Ball Bearing Co. 48
Chapman Valve Mfg. Co. 36
Cincinnati Gear Cutting Machine Co. 27
Cincinnati Shaper Co. 28
Clarkson School of Technology. 26
Cleveland Crane & Engineering Co. 18, 43
Cleveland Pneumatic Tool Co. 31
Conard, William R 26
Crosby Steam Valve & Gage Co. 36

Dallett Co., Thos. H. 31
Darley Engineering Co. 43
Davidson Co., M. T. 40

Page
Dean, F. W. 26
Deane Steam Pump Co. 40
Dearborn Drug & Chemical Wks. . . . 36
Detroit Lubricator Co. 15, 36
Diamond Chain & Mfg. Co. 21, 46
Dixon Crucible Co., Joseph 36
Dodge Co., J. M. 18, 44
Dodge Mfg. Co. 22, 46
Du Bois Iron Works. 13, 34

Eastern Machinery Co 44
Electric Controller & Mfg. Co. . . 17, 44
Engineer Co. 37
Engineering Schools & Colleges. 26
Erie City Iron Works. 32
Errington, F. A. 6, 28
Exeter Machine Works. 42

Fay Machine Tool Co 28
Fellows Gear Shaper Co. 28
Frick Co 48

Gas Power Co. 34
General Electric Co. 24, 47
Golden-Anderson Valve Specialty Co. 14, 37
Goyne Steam Pump Co. 40
Grant Manufacturing & Machine Co. 28

Hanna Engineering Works. 39
Harrisburg Foundry & Machine Works. 32
Heine Safety Boiler Co. 13, 32
Herrick, J. A. 26
Hill Clutch Co. 46
Holyoke Machine Co. 41
Homestead Valve Mfg. Co. 37
Hooven, Owens, Rentschler Co. . 13, 33
Hughson Steam Specialty Co. 37
Hurley & Co., D. 26
Hyatt Roller Bearing Co. 48

Ingersoll Milling Machine Co. 28
International Machine Tool Co. 28

Jacobson Engine Co. 34
Jeanesville Iron Works Co. 25, 41
Jeffrey Mfg. Co. 21, 44
Jones & Lamson Machine Co. . 2, 3, 28

Kellogg Co., M. W. 48
Kennedy Valve Mfg. Co. 15, 37
Knowles Steam Pump Works. 41

Page
Laidlaw-Dunn-Gordon Co. 31
Le Blond Machine Tool Co., R. K. 29
Leschen & Sons Rope Co., A. 44
Lidgerwood Mfg. Co. 44
Lindstrom, John T. 15, 37
Link-Belt Co. 20, 44
Link Chain Belt Co. 18, 44

McCord & Co. 37
McGowan & Co., John H. 41
Main, Chas. T. 26
Manning, Maxwell & Moore 5, 29
Mason Regulator Co. 7, 37
Mietz Iron Foundry & Machine Works, August 34
Moran Flexible Steam Joint Co. 38
Morehead Mfg. Co. 38
Morgan Engineering Co. 45
Morris Machine Works 25, 41
Morse Twist Drill & Machine Co. 5, 29
Murray Iron Works Co. 10, 33

National Brake & Clutch Co. 46
National Machine Co. 29
National Machinery Co. 5, 29
National Meter Co. 9, 34
Nelson Valve Co. 12, 38
Newark Gear Cutting Machine Co. 6, 29
New York University School of Applied Science 26
Niagara Machine & Tool Works 29
Nicholson & Co., W. H. 38
Niles-Bement-Pond Co. 1, 29
Northern Engineering Works 19, 45
Nye Steam Pump Works 41

Ohio Elevator & Machine Co. 45
Ohio Injector Co. 38
Oneida Steel Pulley Co. 47
O'Neill, J. G. 26

Pennsylvania Flexible Metallic Tubing Co. 38
Polytechnic Institute of Brooklyn 26
Poole Engineering & Machine Co. 47
Powell Co., The Wm. 38
Power & Mining Machinery Co. 35
Power Plant Specialty Co. 38
Professional Cards 26
Providence Engineering Works 33

Quimby, Wm. E. 41

Page
Quint, A. O. 30

Reliance Electric & Engineering Co. 47
Rensselaer Polytechnic Institute 26
Ridgway Dynamo & Engine Co. 10, 33
Risdon-Alcott Turbine Co. 41
Riverside Engine Co. 13, 35
Robb-Mumford Boiler Co. 11, 33
Robins New Conveyor Co. 45
Rockwood Manufacturing Co. 47
Roebling's Sons Co., John A. 20, 45
Root & Van Dervoort Engineering Co. 35
Ruggles-Coles Engineering Co. 42
Russell, Burdsall & Ward Bolt and Nut Co. 6, 30

Shaw Electric Crane Co. 45
Siemens-Schuckertwerke 47
Simmons Co., John 7, 39
Skinner Chuck Co. 30
Smith Co., S. Morgan 42
Snow Steam Pump Works 42
Standard Tool Co. 5, 30
Stroudsburg Engine Works 45
Struthers-Wells Co. 9, 35
Sturtevant Co., B. F. 42
Superior Gas Engine Co. 35

Tufts College 26

University of Michigan 26

Wagner Electric Mfg. Co. 47
Walch & Wyeth 11, 39
Waltham Machine Works 30
Warner & Swasey Co. 1, 30
Washburn Shops 6, 30
Webster Mfg. Co. 45
Wetherill & Co., Robt. 33
Wheeler Condenser & Engineering Co. 39
Wheeler Mfg. Co., C. H. 14, 39
Wheelock, Lovejoy & Co. 31
Whiting Foundry Equipment Co. 19, 39
Whiton Machine Co., D. E. 4, 31
Wiley & Russell Mfg. Co. 31
Willoughby, A. B. 39
Wing Mfg. Co., L. J. 42
Wisconsin Engine Co. 7, 33
Worthington, Henry R. 42

Yale & Towne Mfg. Co. 17, 46

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